JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVII. APRIL, 1889. NO. 4.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

FIRE ISLAND INLET.

IS IT MOVING EAST OR WEST, AND AT WHAT RATE?

BY LEWIS M. HAUPT.

In a recent discussion before the Committee on Science and the Arts relative to the comparative effects of wind *vs.* tide in producing changes along the alluvial coasts and at harbor entrances of the United States, the writer supported the theory that the resultant direction of the natural forces acted in certain definite directions at various parts of the coast and that these directions conformed in general to those of the flood tide, and were not due chiefly to prevailing winds, as is generally supposed.

In support of this theory numerous instances were cited, and amongst others the westward progression of the spits and inlets on the outer or south shore of Long Island.

On the other hand, it was urged by a member of the committee that the theory was inconsistent with the fact, and Prof. Henry Mitchell, of the U. S. Coast and Geodetic Survey, was quoted as saying that

"The motion of the waves is not always in the direction of the prevailing winds. * * * An example of this is shown by the action of the waves on the north side of Long Island, N. Y., which drifts the material westward, while on the south side the motion of the drifted material is eastward, and yet the prevailing winds must be the same on the two sides of the island."

The above paragraph was quoted, not to show that the winds did not always blow from the right quarter, but that Professor Mitchell was authority for the statement that the *drift on the south side of Long Island is eastward*, whereas the theory the writer supported required it to be westward. There was produced, also, a coast survey chart of Fire Island Inlet to demonstrate the alleged fallacy of this theory.

At this point the discussion was terminated abruptly, leaving erroneous impressions detrimental to scientific truth, and showing the danger of generalizing from special cases.

What Professor Mitchell states is true, but only for a limited portion of the eastern end of the island, where, during the entrance of the flood tide into the sound, a draft current is produced around Montauk, but for nearly the entire length of the shore line the movement is westerly, as stated. To leave no doubt as to this point, as well as to show the errors liable to arise from comparing the relative volumes of the sand-bars on either flank of a navigable channel, an official copy was obtained from the U. S. Coast and Geodetic Survey Office, of the comparative surveys of the point in question for the years 1835 to 1873 and 1887, showing some definite yet not unusual features. The accompanying chart reduced therefrom needs but little interpretation, for it is seen at once that during the fifty-two years, from 1835 to 1887, the eastern point of Fire Island Beach has advanced westerly about 9,960 feet, or nearly two (2) miles. The

average rate was 186 feet per annum, which is about the same as that on the Texas coast near Aransas Pass. From 1835 to 1873 the movement was at the rate of 170 feet, and during the later period of fourteen years, it was about 220 feet each year. Or if the distance be taken to the western end of the island, now forming in the inlet, it will give about 12,000 feet in fifty-two years, an average of say 230 feet. The general direction of the shore line remains at S. 75° W.

The changes on the inner or receding beach clearly indicate a filling up of the lateral inlets and corresponding progression of the western spit. This filling occurs in lee of the shelter afforded by the overlapping seaward hook, where the sand, which has been travelling westwardly along the outer beach, finds a comparatively quiescent basin into and across which it is carried by the action of both flood and ebb currents, only to renew its journey along shore under the transporting agency of the flood waves.

To remove all doubt as to the facts in the case, the writer addressed a letter to the Hydrographic Office, requesting information from competent observers along this coast. In consequence, the annexed circular was sent to the keepers of the Life-Saving Stations, from a few of whom replies have been forwarded through the courtesy of the office.

SIR:—The Hydrographic Office is desirous of obtaining all possible data regarding the movement of wreckage and other bodies along the shore as affected by wind, waves, currents and tides. This information is desired with special reference to the action of tidal and other currents immediately adjacent to the coast line, with a view of its utilization in considering the formation of bars and the shifting of the coast line at the entrance to our rivers and harbors.

Will be thankful for any information you can furnish on this subject at your earliest convenience.

Shall always be glad to serve you at any time, and hope you will do me the honor of calling upon me, when the occasion arises. I am,

Very respectfully,

[Signed] V. L. COTTMAN,
Lieut. U. S. Navy, in charge.

Although this letter was sent to forty-five stations, replies have been received from but eight.

EXTRACTS FROM REPORTS OF LIFE-SAVING STATION KEEPERS OF THE THIRD U. S. LIFE-SAVING DISTRICT.

Latitude, 40° 47′ 30″.
Longitude, 72° 39′ 00″.

PETUNK STATION, N. Y., January 10, 1889.

"In moderate weather, with small sea, the current changes with each turn of the tide, running west longer than east. From August to May much the heaviest amount of current runs west. During the summer months it runs each way more equally. Heavy wreckage from stranded vessels moves much more west than east. Outlets from all bays along this coast move west. The shore line is slowly working on to the land. About three months after the steamship *City of Columbus* was wrecked at or near Gay Head (west end of Martha's Vineyard), one of her life preservers, made of ground cork and thoroughly water-soaked, was picked up near this station. Part of a schooner, with the official number, that went to pieces inside of Montauk, came ashore here."

[Signed] FRANKLIN C. JESSUP,
Keeper Petunk Life-Saving Station.

Latitude, 40° 35′ 30″.
Longitude, 73° 47′ 20″.

ROCKAWAY STATION, January 4, 1889.

"The currents along the shore here are generally to the west, and the formation of bars are most always shifting from east to west. Wreckage and all substances which are carried by currents are most always carried west. Inlets and shoals are always shifting to the west. Of course, there are exceptions to this, such as heavy west winds, when the current will, for the time, run to the east, but as far as my experience goes the currents are from the north and east to the south and west along the coast.

"I have known a good many wrecks along this coast, and the wreckage would go to the west, but I never 'knowed' of it going to the east.

"The wreckage of the steamship *Oregon* was found as far

south as North Carolina, but I never heard of any being found east, and some years ago there was a schooner ashore east of Fire Island, loaded with cotton. When the wreck broke up the cotton came west as far as this station and to the west of it." *

[Signed] WM. H. REINHART,
Keeper.

Latitude, 40° 34′ 10″.
Longitude, 73° 51′ 50″.

ROCKAWAY POINT STATION, L. I., January 17, 1889.

LIEUT. V. L. COTTMAN, U. S. N.

SIR:—Your circular asking information of wreckage and other bodies along shore is received.

If deeply submerged in the water, ebb tide will carry them east, while flood tide will carry them west. A light substance will float according to the wind. All inlets and shoals work or form to the westward.

[Signed] Respectfully, D. B. ABRAMS,
Keeper.

Latitude, 40° 34′ 20″.
Longitude, 73° 56′ 20″.

CONEY ISLAND L. S. STATION, Manhattan Beach,
January 15, 1889.

LIEUT. V. L. COTTMAN.

SIR:—Yours of the 2d received. * * * About four years ago the sloop *Undine*, while coming in Rockaway Inlet, shipped a sea and sunk. She was at the time on the edge of the east shoals. After about eighteen hours she drifted W. by N. W. (nearly half a mile). Here she laid about stationary for eighteen hours, and then in twelve hours' time reached a point 100 yards S. E. from east end of Manhattan Beach Bulkhead. She dragged bottom the whole of the distance.

A large hawser was lost off a steamboat near where the *Undine* sank (Main Rockaway Inlet), and after about six months came ashore about 300 yards east of Manhattan

* This would be from thirty-five to forty miles.

Beach Bulkhead. * * * Rockaway Beach has been steadily gaining ground to the west. The gain for the last twenty years has been about four miles.

[Signed] R. H. RYDER,
Keeper.

Thus in this range of 1° 17′ of longitude, equivalent, at this latitude, to about sixty-eight miles along the southern coast of Long Island, there is found to exist a progressive westerly movement of the shore line, corresponding to the direction of the bottom currents during the incoming tide. If the rate of growth of Rockaway Beach is correctly stated, it would indicate a more rapid movement, as the tide is compressed towards the gorge at the entrance to New York Bay, between Coney Island and Sandy Hook. From this it would appear that the westerly movement of the beach sand is due chiefly to the direction of the flood tide, rather than to the alleged prevailing direction of the wind or to northeast storms, which here would be off shore.

THE TRANSMISSION OF POWER BY ELECTRICITY.

FRANK J. SPRAGUE.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 12, 1888.*]

(*Concluded from Vol. cxxvii, page 176.*)

In considering the transmission of power, some very curious and valuable facts may be demonstrated by a formula for determining the minimum cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into five parts, that of the motors, the conductors, the line erection, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and

motors is the same per horse-power or other unit, no matter what the electro-motive force used. While this is not strictly true, for all practical purposes, with large units, and speaking from the commercial standpoint, it can be so assumed. This being the case, for any given power the cost of the motor is a constant, independent of the potential used. With any given motor potential, the greater the loss on the line, the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line, the greater its cost, but the less the cost of the generating plant. It follows, then, that the least cost to the contractor is determined when the variation in the cost of the generator is equal to that in the cost of the line, and it is to a consideration of this fact that I wish to call your attention:

We have the formula

$$C\,M = \frac{1492\,n\,m\,l}{E\,v\,a}$$

Let d equal weight of one mil-foot of copper. Then the weight per foot of the copper of our conductor would be

$$\frac{1492\,n\,m\,l\,d}{E\,v\,a} \tag{3}$$

and the total weight for $2\,l$ would be

$$\frac{2984\,n\,m\,l^2\,d}{E\,v\,a} \tag{4}$$

If b is the cost in cents per pound of copper (the cost of insulation being added to cost of copper), we have for the cost of the wire in the line

$$\frac{2984\,n\,m\,l^2\,d\,b}{E\,v\,a} \tag{5}$$

It is to be noted here that this cost b must be expressed so much per pound of copper. It may be that we have a line covered by an insulation of such character that for every dollar's worth of copper there may be $3 or $4 worth of insulation. For example, suppose that a $^1/_0$ B. W. G. wire

be used, covered with an insulation that should make it cost say $150 a thousand feet. The actual weight of copper in the line would be only 350 pounds, which, at $150 market price, would make the wire cost forty-three cents per pound of copper. It is this cost, plus the cost of freight and handling, which must be used as the value of b.

Let E equal the E. M. F. at the terminals of the motor; e, the motor electro-motive force; v, the fall of potential on the line; β, the commercial efficiency of the dynamo; E', the E. M. F. of the generator, and n the number of H. P. developed by the motor. Then we have evidently

$$\frac{e}{E''}$$

as the ratio of the watt capacity of the motor and generator;

$$\frac{n}{a}$$

the H. P. of electrical energy delivered at the motor terminals;

$$\frac{E+v}{E} \times \frac{n}{a}$$

the H. P. of electrical energy delivered to the line, and

$$\frac{E+v}{E} \times \frac{n}{a} \times \frac{1}{\beta}$$

that delivered to the generator.

I think it advisable to make use of the term horse-power and commercial efficiency, for it is partly from the commercial aspect I wish to look at the problem, and it is the side which in business we must confront.

Let us further make K equal the cost in cents of the generators per horse-power required to drive them, and L the similar cost per horse-power of the steam or water plant, all of course erected in place, that is with the cost of freight, handling, insurance, and erection added to the factory or shipping cost. Then the cost per horse-power of the generating plant complete would be:

$$\frac{E+v}{E\,a\,\beta}\, n\,(K+L) \qquad (6)$$

If M is the cost of motor per horse-power developed similarly erected in place, the cost of the receiving plant would be $n\,M$.

We now have one element which is somewhat indeterminate and is dependent chiefly upon distance and local conditions, and that is the cost of pole and line erection, and we will call this P.

Summing up our cost we have the general expressions for the cost per horse-power delivered:

$$C = \frac{E + v}{E\,a\,\beta}\,(K + L) + \frac{2984\,m\,l^2\,d\,b}{E\,v\,a} + M + \frac{P}{n} \qquad (7)$$

It is evident that this is variable, and since the costs of the motor and the line erection are arbitrary, the variation is narrowed down to the cost of the generating plant and the material in the line. It is here apparent, as already pointed out, that if we diminish the cost of the line by increasing the fall of potential, we must at the same time increase the cost of the generating plant, and on the other hand, that if the loss on the line is reduced, its cost will increase, while that of the generating plant will diminish.

Differentiating with v as the variable, we have,

$$\frac{d\,c}{d\,v} = \frac{K + L}{E\,a\,\beta} - \frac{2984\,m\,l^2\,d\,b}{E\,a\,v^2} \qquad (8)$$

or equating to zero

$$\frac{K + L}{\beta} = \frac{2984\,m\,l^2\,d\,b}{v^2} \qquad (9)$$

which is the condition of least cost.

From (9) we have

$$v = 54{\cdot}6\,l\,\sqrt{\frac{m\,d\,b\,\beta}{K + L}} \qquad (10)$$

That is, with fixed conditions of cost and efficiency of apparatus, the number of volts fall to get the minimum cost of plant is a function of the distance alone and is independent of the electro-motive force used at the motor, a somewhat startling conclusion.

Substituting the equivalent value given by equation (9) in (7) we now have for the equation of least cost,

$$C = \frac{E+v}{E\,a\,\beta}(K+L) + \frac{v}{E\,a\,\beta}(K+L) + M + \frac{P}{n} \qquad (11)$$

The first element representing the cost of the generating plant and the second the cost of the wire per the horse-power developed by the motor. The cost of the wire is given as a ratio of the cost per horse-power of the generating plant. From this equation we have the relation:

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{v}{E+v} \qquad (12)$$

This is not, however, in a very useful form, and since the commercial efficiency is that with which we are concerned, we will introduce a term, designating it λ.

We have for the H. P. delivered to the generator,

$$\frac{E+v}{E\,a\,\beta}\,n$$

and n that taken out of the motor; hence we have,

$$\lambda = \frac{E\,a\,\beta}{E+v} \qquad (13)$$

or

$$v = \frac{a\,\beta - \lambda}{\lambda}\,E \qquad (14)$$

Substituting the value of v in equation (11), we have a new form of the cost equation as follows:

$$C = \frac{K+L}{\lambda} + \frac{a\,\beta-\lambda}{a\,\beta\,\lambda}(K+L) + M + \frac{P}{n} \qquad (15)$$

a still simpler formula. We also have the relation,

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{a\,\beta-\lambda}{a\,\beta} \qquad (16)$$

That is, *with any fixed couple and commercial efficiency, the cost of the wire should bear a definite and fixed ratio to the cost of the generating plant.*

But the query arises at once, is this so, no matter what the cost of the copper? And the answer is an affirmative one, and why this is so will soon be apparent.

Referring to the equation (10) and substituting for m its approximate value, 10·5, and for d its value, ·00000302705, we have:

$$v = \cdot 308\, l \sqrt{\frac{b\,\beta}{K + L}} \tag{17}$$

Combining this with (13), we find that

$$E = \frac{\cdot 308\, l\, \lambda}{\alpha\,\beta - \lambda} \sqrt{\frac{b\,\beta}{K + L}} \tag{18}$$

We now see what influence the cost of copper has when the commercial efficiency is maintained constant, which is to vary the value of E as it increases, but only as the square root of such increase. It will be noticed also that a variation in $K + L$ inversely affects E and v likewise as the square root.

It follows from the above that if we do not limit ourselves in the E. M. F. used, the cost per H. P. delivered exclusive of line erection, is, for least cost and for a given commercial efficiency, absolutely independent of the distance.

We are met at times with the condition that the motor potential shall not be above a given amount, and from the formula,

$$E = \frac{\cdot 308\, l\, \lambda}{\alpha\,\beta - \lambda} \sqrt{\frac{b\,\beta}{K + L}}$$

transposed to

$$\lambda = \frac{E\,\alpha\,\beta}{\cdot 308\, l \sqrt{\frac{b\,\beta}{K + L}} + E} \tag{19}$$

we find at once what the efficiency of the transmission must be with a given distance, and therefore whether it is worth while to attempt the operation. On the other hand, if, for example, we make our lower limit of commercial efficiency 50 %, $\alpha\,\beta = 80$ %, and $\beta = 90$ %, we have a limiting equation.

$$E = .487\, l \sqrt{\frac{b}{K + L}} \tag{20}$$

Since the circular mils vary inversely with $E\,v$, the size,

weight and cost of the wire vary directly as the cost of the generating plant, which we have already seen from another formula. To get a matter-of-fact idea of this, I will assume some values, as follows:

Let $K = \$45.00$, $L = \$20.00$ (say for a water-power), $M = \$50.00$, and $b = 25$ cents for copper delivered on the ground.

Then we would have our formulæ for this particular case reduced to the following:

$$v = \frac{4 - 5\lambda}{5\lambda} E \tag{21}$$

$$v = .0181\, l \tag{22}$$

$$E = \frac{.0905\,\lambda}{4 - 5\lambda} l \tag{23}$$

and

$$\lambda = \frac{4E}{5E + .0905\, l} \tag{24}$$

which will give us the required elements of any single transmission under these conditions.

For example, suppose we wish to transmit 20,000 feet. The fall of potential on the line could be 362 volts, and this is independent of the commercial efficiency. If this latter is made, say sixty per cent., then $E = 1{,}086$ volts, and the potential at the terminals of the generator should be 1,448 volts. On the other hand, suppose we want to transmit a distance of 10,000 feet with a motor terminal potential of 800 volts, then $\lambda = 65$ per cent., and $v = 181$ volts.

We can, as I will soon show, make a graphic representation of these facts, which will save much labor and will give at a glance the various limitations.

Referring to the general equation we can make, for various efficiencies, a table as follows:

$\lambda = 50\ \%$ $\quad C = 2K + 2L + \frac{3}{4}(K + L) + M + \frac{P}{n}$

$55\ \text{“}\quad \text{“}\quad \frac{21}{11}K + \frac{21}{11}L + \frac{21}{44}(K + L) + M + \frac{P}{n}$

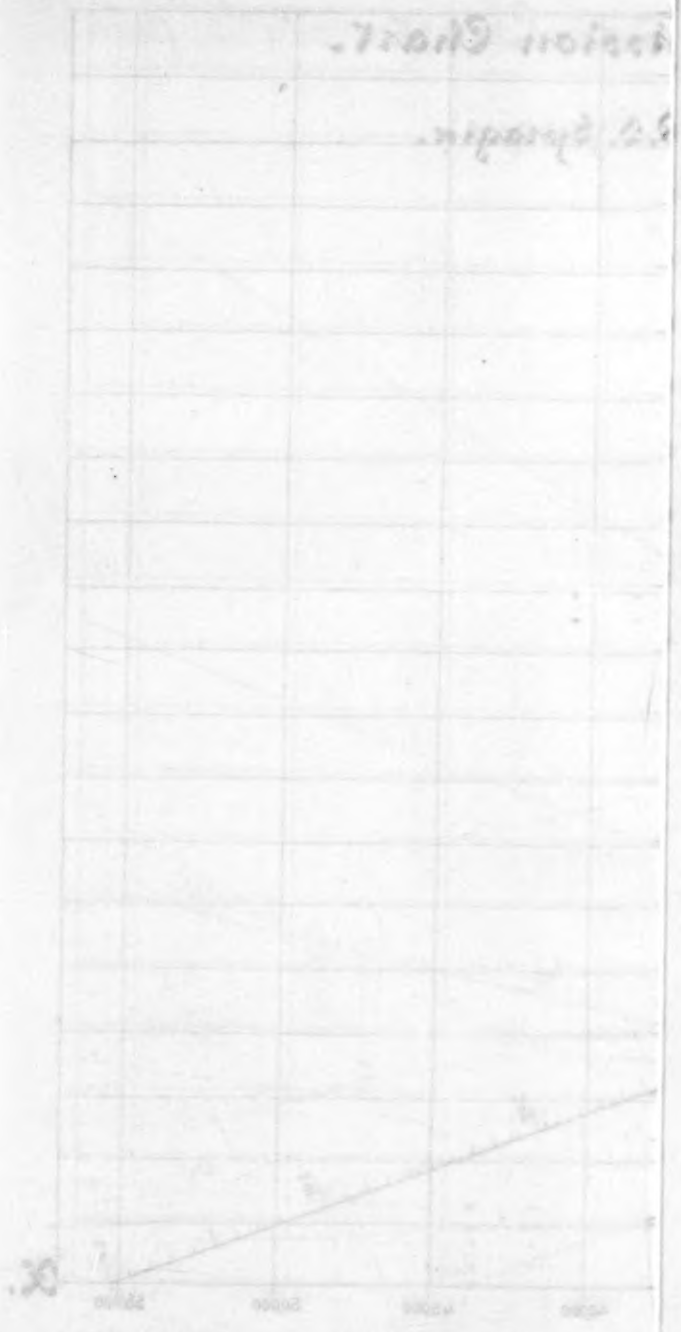
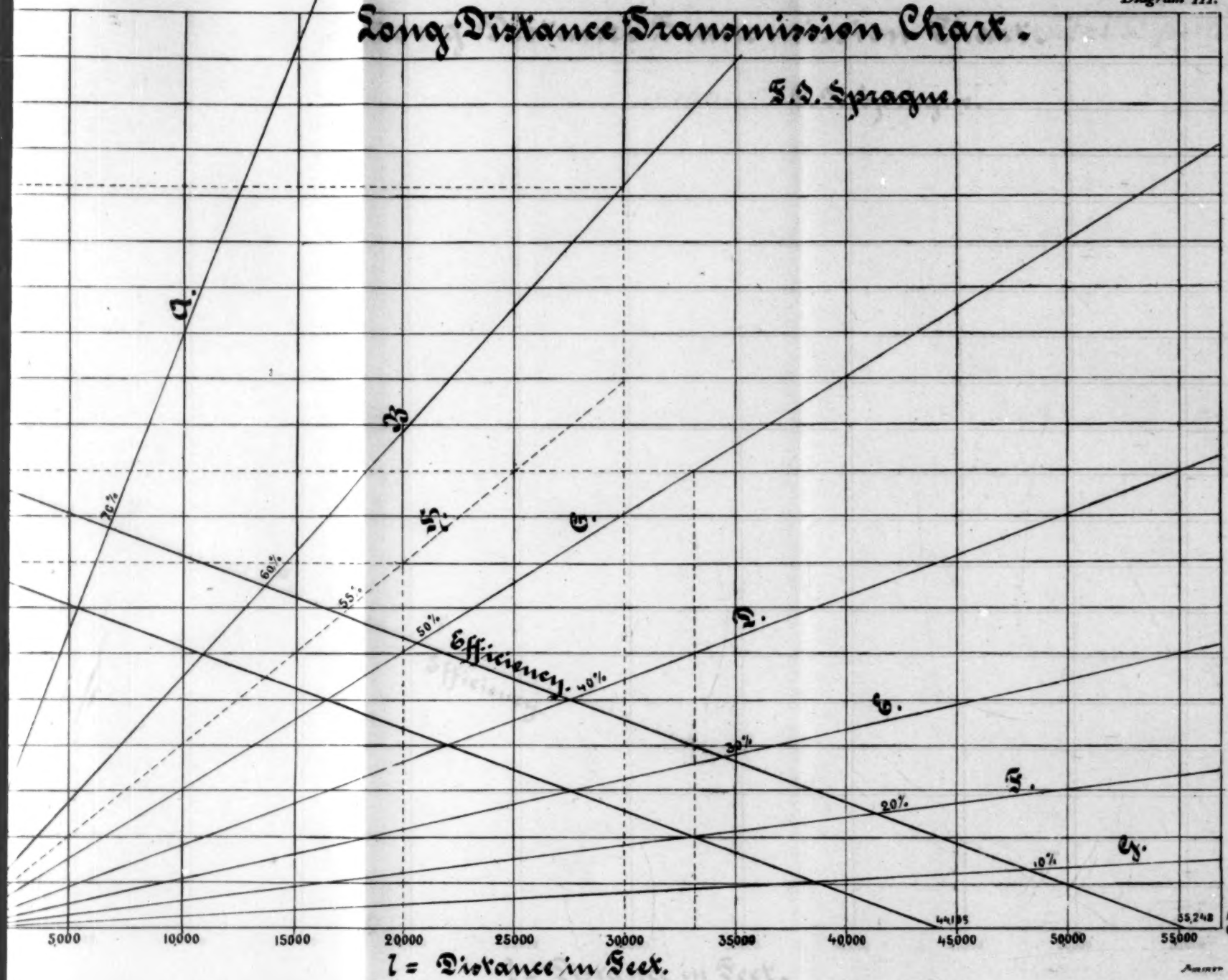


Diagram III.


Long Distance Transmission Chart.
S.D. Sprague.
A.
B.
C.
D.
E.
F.
G.
H.
K.
76%
60%
55%
50%
Efficiency. 40%
30%
20%
10%
44,198
55,248
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
55000
l = Distance in Feet.

$$60\,\%\quad C = \tfrac{5}{6}K + \tfrac{5}{6}L + \tfrac{5}{12}(K+L) + M + \frac{P}{n}$$

$$65\ \text{“}\quad \text{“}\quad \tfrac{20}{13}K + \tfrac{20}{13}L + \tfrac{16}{65}(K+L) + M + \frac{P}{n}$$

$$70\ \text{“}\quad \text{“}\quad \tfrac{10}{7}K + \tfrac{10}{7}L + \tfrac{5}{28}(K+L) + M + \frac{P}{n}$$

$$75\ \text{“}\quad \text{“}\quad \tfrac{4}{3}K + \tfrac{4}{3}L + \tfrac{1}{12}(K+L) + M + \frac{P}{n}$$

$$80\ \text{“}\quad \text{“}\quad \tfrac{5}{4}K + \tfrac{5}{4}L + \quad 0 \quad + M + \frac{P}{n}$$

and substituting the assumed values of K, L and M, we would have for the cost of transmission per horse-power delivered, exclusive of poles and line erection, and independently of the distance, the following table:

Efficiency, Per Cent.	*Water-Power.*	*Dynamo.*	*Wire.*	*Meter.*	*Electrical Total.*	*Water and Electrical.*
50	$40 00	$90 00	$48 75	$50 00	$188 75	$228 75
55	36 36	81 81	36 94	50 00	168 75	205 11
60	33 33	75 00	27 08	50 00	152 08	185 41
65	30 77	69 23	18 75	50 00	137 98	168 75
70	28 57	64 28	11 61	50 00	125 89	154 46
75	26 67	60 00	5 42	50 00	115 42	142 09
80	24 00	56 25	. . .	50 00	106 25	130 25

The graphic representation of the facts which have been set forth, and the construction of an electrical reference table, which will at once show the necessary elements, is a simple matter.

We have the equation.

$$E = \frac{\cdot 0905\,\lambda}{4 - 5\lambda}\,l$$

Let us lay off on the axis of x the distance in feet and on the axis of y the E. M. F. at the motor terminals.

Then for any value of λ the ratio of

$$\frac{E}{l}$$

is fixed, whatever the actual value, and we can draw the efficiency lines $O\,A$, $O\,B$, etc., for

$$\lambda = 70\%,\ 60\%,\ \text{etc.},$$

which will, with the different values of l and E, give us any required information. This, however, is not yet in a convenient and general form, and we wish to get some general intersecting efficiency line. By an inspection of the diagram we see that if a general efficiency line can be drawn, it must intersect the specific efficiency lines at such an angle that the intersected portions must be proportional to the differences of efficiencies. In other words, we must have the ratio

$$\frac{E}{\lambda}$$

for any particular value of E constant. Referring to the above equation and transposing we have,

$$\frac{E}{\lambda} = \frac{5\,E + \cdot0905\,l}{4} \qquad (25)$$

It is evident that if we are to get this equation to give a straight line, we must make the condition

$$\frac{E}{\lambda}$$

a constant, r. Substituting we have—

$$\frac{E}{\lambda} = r$$

and

$$r = \frac{5\,E + \cdot0905\,l}{4}$$

which will give in a series of parallel straight lines for various values of r and E corresponding.

Let $r = 1000.$

Then we have—

$$E = 1000\,\lambda$$

and

$$E = \frac{4\,r - \cdot0905\,l}{5}$$

When

$$E \text{ and } \lambda = 0,\ 4\,r = \cdot0905\,l$$

or

$$l = 44199,$$

and when $l = 0,$

$E = 800$

and $\lambda = 80\%.$

Plotting this, we have a general efficiency line. Assuming another value for r, we get another straight line parallel to this, but one line is sufficient. It is, however, of prime importance. On it we lay off the efficiency percentages in equal increments, from 0 to 80%, and the chart which needs consist only of the axes of x and y, on which the E. M. F. and distance are laid off, and the efficiency intersecting line is ready for constant reference, and will give at a glance the graphic solution of all the ordinary elements of a transmission under the condition of least prime cost, and with the known efficiency of motors and dynamos. For example, suppose we wish to transmit a distance of 30,000 feet at a commercial efficiency of sixty per cent., what would be the required E. M. F. at the motor terminals? Drawing the efficiency line *O B* till it meets the ordinate erected at $l = 30{,}000$, we find the E. M. F. to be 1,620 volts. On the other hand, suppose we are limited to 1,000 volts at the motor, and must have an efficiency of fifty per cent., what would be the limiting distance? Reversing the above process, we find it to be 33,500 feet. Suppose, again, that we must operate at a distance of 20,000 feet, and are likewise limited to an E. M. F. of 800 volts at the motor, what would be the required efficiency? Through the intersection of the co-ordinates of electro-motive force and distance, we draw the efficiency line *O H*, and at its intersection find the efficiency to be about fifty-five and one-half per cent. Such, then, is this method of graphic determination.

Commercial practice, however, may make it inadvisable to meet every phase of a transmission just as the theory may demand, and since in manufacture it may be advisable to build motors for three standard potentials, say, for 400, 800 and 1,200 volts, allowing the dynamo to be driven at the E. M. F. demanded by theory, we may be required to make a table something like the following. It will be noted that the prices here differ somewhat from those given in the preceding examples, and are illustrative rather than perfectly accurate.

Distance in Feet.	E. M. F. at Terminals of Motor.	Commercial Efficiency.	Per Horse-power Delivered by Motor. Horse-power required at Dynamo.	Weights in Pounds. Dynamo. Net.	Dynamo. Gross.	Motor. Net.	Motor. Gross.	Cost in Dollars and Cents. Wire, underground.	Water-power.	Dynamos, etc.	Uncovered Wire, etc.	Motor, etc.	Total for Electrical Equipment.	Remarks.
5,000	400	65	133	153	168	97	130	68 88	30 66	61 28	17 22	45 00	123 42	Copper, ... @ $0.25
10,000	"	54	185	185	204	"	"	144 32	37 00	74 00	36 08	"	135 08	Dynamos, ... @ $20.00
15,000	"	47	233	213	234	"	"	210 88	48 60	85 32	50 78	"	185 92	Motors, ... @ $2.45
5,000	800	71	141	141	155	"	"	30 68	28 24	58 93	9 92	47 50	117 15	Copper, ... @ $0.25
10,000	"	65	153	153	168	"	"	71 72	30 60	71 93	17 93	"	130 26	Dynamos, ... @ $15.00
15,000	"	59	189	189	186	"	"	110 92	37 80	71 93	27 78	"	147 86	Motors, ... @ $41.50
20,000	"	54	185	185	204	"	"	150 32	37 00	71 93	37 78	"	167 71	
25,000	"	50	200	200	220	"	"	189 68	40 00	85 00	48 66	"	179 38	Motors, ... @ $47.50
30,000	"	47	213	213	234	"	"	229 04	42 66	90 53	58 32	"	190 95	
35,000	"	43	233	233	256	"	"	268 36	46 66	94 33	68 00	"	208 55	
40,000	"	40	250	250	275	"	"	307 72	50 00	97 53	77 36	"	225 31	
15,000	1,200	65	133	153	168	97	130	68 88	30 66	61 28	17 22	45 00	123 42	Copper, ... @ $0.25
20,000	"	57	175	175	193	"	"	107 28	35 00	71 93	27 78	"	137 50	
25,000	"	54	185	185	204	"	"	146 72	37 00	71 93	37 78	"	149 13	Dynamos, ... @ $15.00
30,000	"	51	196	196	216	"	"	186 16	39 20	71 93	47 78	"	167 45	
35,000	"	48	208	208	229	"	"	225 60	41 60	85 00	58 46	"	172 33	Motors, ... @ $47.50
40,000	"	45	222	222	244	"	"	265 04	44 40	90 53	68 00	"	184 38	
45,000	"	43	233	233	256	"	"	304 36	46 66	94 33	77 36	"	193 18	
50,000	"	40	250	250	275	"	"	343 80	50 00	97 53	87 11	"	208 96	
30,000	1,600	65	133	153	168	97	130	68 88	30 66	61 28	17 22	45 00	123 42	Copper, ... @ $0.25
40,000	"	59	189	189	186	"	"	147 72	37 80	71 93	37 78	"	147 86	
50,000	"	54	185	185	204	"	"	186 16	37 00	71 93	47 78	"	167 71	Dynamos, ... @ $20.00
60,000	"	50	200	200	220	"	"	225 60	40 00	85 00	58 46	"	179 38	
70,000	"	47	213	213	234	"	"	265 04	42 66	90 53	68 00	"	190 95	Motors, ... @ $47.50
80,000	"	43	233	233	256	"	"	304 36	46 66	94 33	77 36	"	208 55	
90,000	"	40	250	250	275	"	"	343 80	50 00	97 53	87 11	"	225 31	
40,000	"	65	133	153	168	97	130	68 88	30 66	61 28	17 22	45 00	123 42	Copper, ... @ $0.25
50,000	"	61	175	175	193	"	"	107 28	35 00	71 93	27 78	"	137 50	
60,000	"	57	175	175	193	"	"	146 72	35 00	71 93	37 78	"	149 13	Dynamos, ... @ $15.00
70,000	"	54	196	196	216	"	"	186 16	39 20	71 93	47 78	"	167 45	
80,000	"	51	204	204	224	"	"	225 60	40 80	85 00	58 46	"	172 33	Motors, ... @ $50.00
90,000	"	48	213	213	234	"	"	265 04	42 66	90 53	68 00	"	184 38	
100,000	"	45	228	228	244	"	"	304 36	44 40	94 33	77 36	"	193 18	
50,000	"	43	233	233	256	"	"	343 80	46 66	97 53	87 11	"	208 96	
60,000	"	40	250	250	275	"	"	383 24	50 00	97 53	96 95	"	213 72	

NEW FORMS OF VENTURI TUBES.

[From the Annals of the Laboratories of the Department of Civil Engineering of Cornell University. Section of Hydraulic Research. Preliminary Investigation by Prof. I. P. Church, Superintendent of the Hydraulic Laboratory.]

Having recently designed and made a few experiments with the two forms of short pipes or tubes to be described below (and there called B and C), for the discharge of water from the side of a large vessel, the writer finds his expectations so far realized as to venture to speak of them as "new forms of Venturi tubes."

In all records, accessible to him, of experiments on the discharge of water through short pipes having conically divergent interior walls, stress has always been laid on the circumstance, so surprising to the novice, that a greater rate of discharge takes place than would occur through an orifice in thin plate, or through a short cylindrical pipe, having an area of discharge equal to the sectional area at the *narrowest* part of the Venturi tube. Again, in Mr. Francis' experiments (Lowell Hydraulic Experiments) the discharge was made under water, to ensure the filling of the tubes; and in none of his experiments was a higher co-efficient of efflux attained than 0·782; understanding by the co-efficient of efflux the abstract number μ in the following formula (to be used in this paper):

$$\mu = \frac{Q}{F\sqrt{2gh}} \qquad (1)$$

where Q is the volume of water discharged in a unit of time; h the "head" (or vertical distance of the centre of the discharging orifice from the surface of the still water in the supply tank when the discharge is into the air, or the difference of level between the surfaces of the head and tail waters when the discharge takes place under water); while

F is the internal sectional area of the discharging end of the tube, and g the acceleration of gravity.

The special feature of the pipes now to be described is that they enable a greater discharge to occur than through an ordinary cylindrical short pipe with an internal diameter equal to that of the *widest* part of the former; or, to express it in a form rather paradoxical to the uninitiated, a greater discharge may be obtained by *partially filling up*, in a special manner, the interior of a short pipe originally cylindrical, than with the same pipe before this encroachment

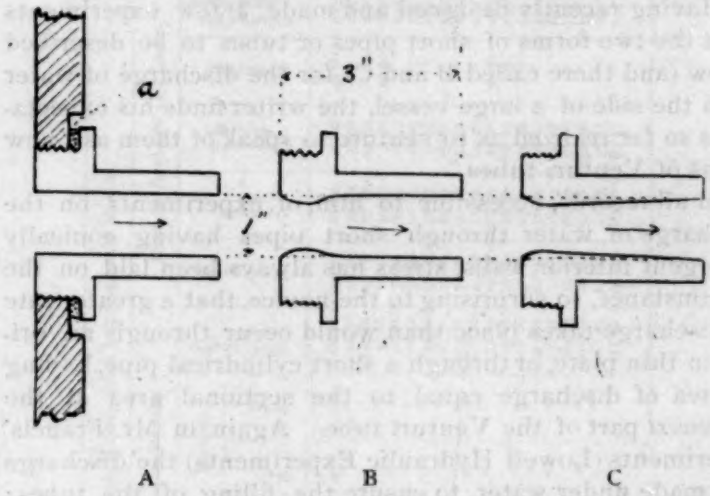


FIG. 1.

on the passage-way, under the same head. Another way of putting it would be to say that while the Venturi tube as previously constructed discharges more water than the *inscribed* cylindrical surface, those now under consideration discharge more than the *circumscribed* cylinder.

It is well known (see p. 467 of "Hydromechanics," *Encyc. Britan.*) that when a pipe conducting water includes a portion containing a smooth and gradual enlargement of sectional area (the change of size not being extreme, not more than 10 to 6, say, but little loss of head occurs on this account during steady flow with full sections, the loss of

kinetic energy being made good by a (nearly) equivalent gain of "pressure energy," provided that the discharging end of the pipe is at some distance away. It therefore seemed probable to the writer that a considerable portion of the loss of head (about one-third of the total head in such a case) occurring during flow through a short cylindrical pipe might be prevented, and the discharge correspondingly increased, by smoothly guiding the stream in its enlargement from the narrow part of the *vena contracta*, together with filling up with solid material the space around the contracted vein, otherwise occupied by eddying water.

The three tubes, *A*, *B* and *C*, of *Fig. 1*, which shows longitudinal sections through their axes of figure, all cross-sections being circular, were therefore constructed; being made of brass, and with smooth internal surfaces. In all three tubes the sections at entrance and also those at the discharging ends are circles of one inch diameter, while the length of each is three inches.

Tube *A* is an ordinary straight cylindrical tube.

In *B*, the internal surface follows the form of the *vena contracta*, as it would occur with an orifice in thin plate, until reaching a point 0·50 inch from the plane of entrance, at which point the diameter is 0·80 inch, following Weisbach's measurement of the contracted vein (see Coxe's *Weisbach*, page 822), while in the next half inch of length, by a smooth reversed curve, the longitudinal profile regains the original full diameter of one inch, the remaining two inches of the tube being cylindrical.

In *C*, as in *B*, the interior is made to fit the contracted vein for the first half inch of length, the remainder being conically divergent until at exit the diameter is one inch. The junction of the straight line and the curve is smoothly rounded in longitudinal profile.

The Hydraulic Laboratory of the Civil Engineering Department at Cornell is provided with a hydraulic "regulator" or "pressure chamber," consisting of a strong cylinder of cast iron, one foot in internal diameter, the ends being composed of two discs or plates, twenty inches apart (see *Fig. 2*). Each of these plates has a central aperture,

2·25 inches in diameter and furnished with a screw thread. Into the aperture at one end of the "regulator" is fitted a two-inch supply pipe, connecting with the reservoir main and provided with a valve gate, while that in the other plate serves as a nut, or socket, into which may be inserted any mouth-piece or pipe with which it is desired to experiment.

The axis of the "regulator" is horizontal and by proper management of the valve *V*, in the supply pipe, a pressure may be maintained in the chamber from one atmosphere

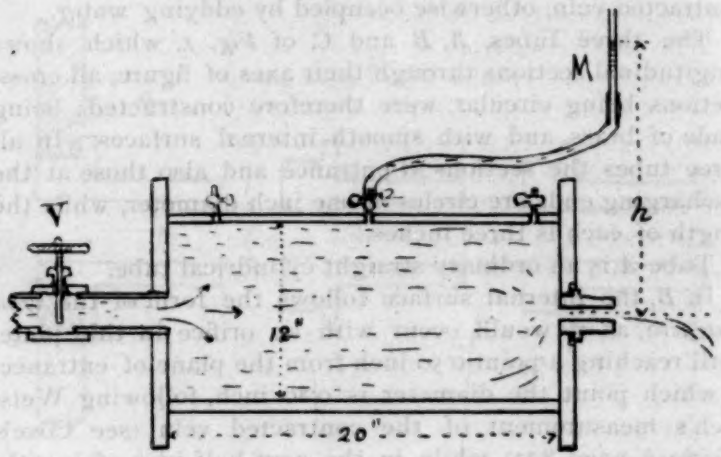


FIG. 2.

(absolute) up to the hydrostatic pressure due to the reservoir-head of about eighty feet, according to the rate of flow permitted to take place and the size of the attached mouth-piece or other fitting. This internal pressure can be measured by a mercury manometer of the U-form, over nine feet in height, one branch of the tube being open to the air; or, when small, by the height of a water column *M*, in a glass tube; connections of rubber tubing being made to pet-cocks inserted in the upper side of the "regulator." The internal section of the chamber being very large, compared with that of any pipe or mouth-piece used in connec-

tion with it, the water is in most experiments considered to have no appreciable "velocity of approach." In the experiments with the short pipes, above mentioned, the head was measured from the middle of the pipe section to the top of the water column in the glass tube connecting with one of the pet-cocks, the air originally in the apparatus having first been entirely displaced by water, and the pipe having been screwed into the socket no further than necessary to make the internal vertical plane of the former flush with that of the latter. A rubber washer of proper thickness prevented leakage. See *a*, *Fig. 1*.

The jet flowing from the pipe was received in one end of a conductor pipe, properly inclined, from the other extremity of which the stream could be allowed to run to waste in the drain, or, by a sudden shift, to empty into the measuring tank. The latter was of galvanized iron, twenty inches deep and two feet square horizontally, resting on the platform of a Fairbank's scale of 400 pounds capacity. The duration of flow was observed by a watch; with the chance of an error of no more than a quarter second, probably, in each experiment. Longer times of flow than those employed would have diminished the importance of this error, but a limit was set by the size of the measuring tank. For a similar reason the greatest head used was four feet.

Another source of slight inaccuracy lay in the fact that the pressure in the reservoir main was subject to frequent fluctuations, producing corresponding oscillations in the water column in the glass tube serving as manometer. In no experiment, however, was the range of oscillation more than three or four hundredths of a foot and in very few as much as that; the average position of the column being estimated. As already stated, the discharge took place into the air. The end of the tube was visibly filled in each experiment, and the temperature of the water was about 40° F. The weight of the water in the tank was observed at the beginning and end of each experiment, readings being taken to the nearest quarter pound. Assuming a cubic foot of water to weigh 62·5 pounds, the total volume discharged was computed in an obvious manner, as well as

the volume per minute. Referring to equation (1) as the basis of computation, we have in each case $F = 0{\cdot}005454$ square feet; and

$$\sqrt{2g} = 8{\cdot}02$$

(for the foot and second), according to the table given on p. 19 of Mr. Hamilton Smith's *Hydraulics*. Hence with Q expressed in cubic feet per minute, equation (1) becomes

$$\mu = \frac{Q \text{ (in cubic feet per minute)}}{60 \times {\cdot}005454 \times 8{\cdot}02 \sqrt{h} \text{ (in feet)}} \qquad (2)$$

The annexed table shows the results of the experiments, both as to observed and computed quantities. In the last column are given the averages for μ in the case of each pipe under two feet head (approximately) and, also, under four feet head, to show the influence of a change of head. The increased discharge given by tube *C* over that of *A* is very marked; while the performance of *B*, notwithstanding the fact that its enlargement of section is much more abrupt than with *C*, is only slightly behind that of the latter, which seems to show that the filling-up around the *vena contracta*, a feature common to both *B* and *C*, is the most essential condition of their superiority to *A*.

With the increased facilities of a new laboratory in the special building now in process of construction, it is hoped to repeat these experiments under more favorable conditions, and to employ a much greater range of heads, as well as a variety of sizes of pipe.

Tube employed.	Number of Experiment.	Observed Quantities.				Computed Quantities.				
		Head in Feet (h).	Duration in Seconds.	Initial Weight. Pounds.	Final Weight. Pounds.	Total Weight. Pounds.	Total Volume. Cubic Feet.	Volume per Minute. Cubic Feet (Q).	Co-efficient of Efflux μ.	Averages for μ.
A	1	2·0	60	100·5	287·0	186·5	2·984	2·984	·804	·814
	2	2·0	60	82·0	271·0	189·0	3·024	3·024	·815	
	3	2·0	60	98·0	289·0	191·0	3·056	3·056	·823	
	4	2·02	60	119·5	309·0	189·5	3·032	3·032	·813	
	5	4·03	45	64·5	267·5	203·0	3·248	4·331	·822	·821
	6	4·02	45	76·0	278·0	202·0	3·232	4·309	·819	
	7	4·02	45	84·75	287·75	203·0	3·248	4·331	·823	
B	8	2·02	60	110·0	314·0	204·0	3·264	3·264	·875	·882
	9	2·0	60	112·5	316·5	204·0	3·264	3·264	·880	
	10	2·0	45	103·5	257·5	154·0	2·464	3·285	·885	
	11	2·0	60	85·0	290·5	205·5	3·288	3·288	·886	
	12	1·99	60	89·5	294·5	205·0	3·280	3·280	·886	
	13	3·96	45	74·75	293·0	218·25	3·492	4·656	·891	·892
	14	3·97	45	100·5	320·0	219·5	3·512	4·683	·896	
	15	3·97	45	101·5	317·5	216·0	3·456	4·608	·881	
	16	3·97	45	101·5	322·5	221·0	3·536	4·715	·902	
C	17	1·98	60	53·0	265·0	212·0	3·392	3·392	·919	·901
	18	1·98	60	84·0	291·5	207·5	3·320	3·320	·899	
	19	2·0	60	103·5	312·0	208·5	3·336	3·336	·898	
	20	2·0	60	103·5	310·0	206·5	3·304	3·304	·890	
	21	2·01	60	70·5	279·0	208·5	3·336	3·336	·897	
	22	4·0	30	97·0	245·0	148·0	2·368	4·736	·902	·914
	23	4·06	45	65·5	293·5	228·0	3·648	4·864	·920	
	24	4·04	45	68·5	294·0	225·5	3·608	4·811	·912	
	25	4·05	45	59·5	288·0	228·5	3·656	4·875	·923	

Ithaca, January 15, 1889.

DIFFERENTIAL METHOD OF COMPUTING APPARENT PLACES OF STARS FOR LATITUDE WORK.

By Erasmus D. Preston, Coast Survey Office, Washington, D. C.

[*Published by permission of the Superintendent of the U. S. Coast and Geodetic Survey.*]

When a number of stations have been occupied during a season for the determination of latitude, the necessary reductions of the stars from mean to apparent positions requires considerable time. With a view of accomplishing the task sooner, as well as making the work much less laborious, and at the same time having an accuracy fully equal to the requirements of the case, the following investigation was made. Although the superiority of this method is most marked when the observations only extend over three or four days, and when several stations with long star lists are to be reduced at one time, yet in any case it is considerably shorter than the usual logarithmic method. Little is gained by observing a star more than three times; and with the improved mean star places now available and allowing a probable error of observation of 0″·50 for an experienced observer, with good weather, three evenings work will reduce the uncertainty of the latitude to about ten feet. So that this method may be employed nearly always with great advantage.

The usual computation of the apparent places of stars for the dates of observation may be abridged in two ways: first, in using Crelle's tables instead of making the ordinary four-place logarithmic computation; and, second, after having one date getting a neighboring date by the application of differential quantities derived from the usual formulæ.

If we consider the tabular differences of the quantities that vary with the date as the differential coëfficients of the

quantities with respect to the time at the date already computed, we have the following formulæ as representing the change in declination between the two dates:

$$-g\,d\,G\sin(G+a)+dg\cos(G+a)$$

$$[-h\,d\,H\sin(H+a)+dh\cos(H+a)]\sin\delta$$

$$di\cos\delta$$

The following relations exist between the independent star numbers:

$$G=\tan^{-1}\frac{B}{KA}\qquad H=\tan^{-1}\frac{C}{D}$$

$$g=\frac{B}{\sin G}\qquad h=\frac{C}{\sin H}\qquad i=C\tan\omega$$

Where the letters have the signification given in the American ephemeris, K is the precession constant 20″·0533.

The greatest departure from a uniform change for a five-day period in B and A, is due to terms depending on the moon's longitude. The terms depending on the longitude of the sun, of the moon's ascending node, and on the longitude of the sun's and moon's perigees, being either quite regular for a five-day period, or else being extremely small. In 1887, G does not change as much as 3°; g changes less than 0″·5.

The tangent of H varies inversely as the tangent of the sun's mean longitude. Hence H varies nearly uniformly throughout the year, changing about 1° daily. h depends on the same quantity and has its maximum values at the solstices and its minimum ones at the equinoxes. For a five-day period it departs little from a uniform change. i varies also with the sun's longitude and has its maximum with the minimum h and *vice versa*. The greatest daily change in i is not much more than 0″·10, while that of h is very much less.

The value of G is in general principally affected by changes in terms depending on the sun's and moon's longi-

tude, and on the longitude of the moon's ascending node. The latter has a daily motion of 3′. The first two have a daily motion of about 1° and 13°, respectively. *tan* G varies directly as B and inversely as A, and since the former depends on the cosines and the latter on the sines of the above functions, they do not both change rapidly at the same time. At 90° *cos* Ω changes 0·005 in five days and the change in *cos* 2 Ω may be neglected. When $\odot = 45°$, *cos* 2 $\odot$ has a change of 0·087. For an equal period and position *cos* 2 $\mathfrak{D}$ changes about one unit. The terms in which these quantities enter will therefore vary by 0″·05, 0″·05 and 0″·09, respectively. Hence the greatest change in B comes from the change in the moon's longitude. In case of all these changes having their maximum at the same time, and tending in the same direction, the value of B would only be changed by about $\frac{1}{50}$th the part of itself, and since

$$d \tan^{-1} y = \frac{dy}{1 + y^2}$$

the change in G dependent on B will not be more than about 1°.

The longitude of the moon's ascending node does not pass through 90° until 1890, but its change is slow compared with that of the others, and in its relation to B we need not for the present consider its effect on G.

The above quantities enter A as a sine function with coëfficients about $\frac{1}{20}$th of those for B, but the precession factor appearing in the denominator of *tan* G makes the changes in numerator and denominator about equal for maximum values of the function. But G being determined by its tangent, the magnitude of its changes depends also on the absolute values of B and A—for when B is small a given change in A has very much more influence on the angle. In general, we may expect changes in G of less than a degree per day.

When we have very small values for B, as in 1890, and also very small values for A, as in May, a combination of these may give a change in G for five days, amounting to

30° or more; but, as will be shown later, this does not render the method inapplicable.

When B has its largest value, G does not change more than, say, 5°, which reduces the product of dg by $d\,G$ to a quantity less than 0″·10, and when $d\,G$ is very large dg is small enough to reduce the product considerably under 0″·10, so that, in general, we may estimate the neglected term to be less than 0″·10. The product of any two of these differences that actually occur together is usually only a few hundredths of a second, so that the method will satisfy all the requirements of latitude work.

These considerations show that the stars' position may be derived, with all necessary accuracy, by the application of differential quantities, when the difference between the two dates is not more than five days. The following two forms show the reduction by both methods. It will be noticed that the method by differences involves only about half the number of figures used in the logarithmic method, besides requiring very little mental labor.

STAR 289.—METHOD BY LOGARITHMS.

	h. m. s.	° ′	*sin δ*	*cos δ*
$\alpha_0 =$	3 11 40	47 55	9·7453	9·9196
$\delta_0 =$		33 48		
	$\delta' - \delta$	$g \cos (G + \alpha)$	$h \cos (H + \alpha)$	$i \cos \delta$
		° ′	° ′	
	January 20th.	151 5	19 9	0·5408
	″	9·9482	9·9753	− 3·4
	— 0·43	0·8751	1·0219	
		− 7·50	+ 10·52	
	January 25th.	148 59	14 15	0·5395
	″	9·9330	9·9864	− 3·8
	— 0·34	0·8499	1·0301	
		− 7·08	+ 10·72	
		January 20th.	*January 25th.*	
		° ′	° ′	
	G	103 10	101 4	
	H	331 14	326 20	
	$\log g$	0·9329	0·9169	
	$\log h$	1·3013	1·2984	
	$\log i$	$0·6212_n$	$0·6799_n$	

STAR 289.—METHOD BY DIFFERENCES.

	h. m. s.	° ′		
$\alpha_0 =$	3 11 40	47 55		
$\delta_0 =$		33 48		
		$(G + a)$	$(H + a)$	
		° ′	° ′	
	January 20th.	151 5	19 9	*January 25th.*
$\sin (G + a)$		+ ·483		+ ·15
$\cos (G + a)$		— ·875	— 7″50	+ ·27
$\sin (H + a)$		+ ·328		+ ·56
$\cos (H + a)$		+ ·945	+ 10″51	— ·12
$\sin \delta$		+ ·556		+ ·24
$\cos \delta$		+ ·831	— 3″47	— ·51
			— 0″46	+ ·15
		January 20th.		
		° ′		
$G =$		103 10	$d G =$	— ·0367
$H =$		331 14	$d H =$	— ·0855
$g =$		+ 8″57	$d g =$	— ·31
$h =$		+ 20″01	$d h =$	— ·13
$i =$		— 4″18	$d i =$	— ·61
			$-g\,d\,G =$	+ ·314
			$-h\,d\,H =$	+ 1″71

EXPLANATION OF COMPUTATION.

In both methods the quantities below the double line are the same for all stars, varying only with the date, and are therefore written but once for each station. The first computation is the usual logarithmic one, and needs no explanation. The second is by Crelle's tables and differences. In the first column are the natural trigonometric functions. In the second are the quantities $g \cos (G + a)$, $h \cos (H + a) \sin \delta$ and $i \cos \delta$, the sum of which is the reduction to apparent place for January 20th. The proper motion of the star is not considered in comparing the two methods. The third column contains the products of the constant multipliers by the corresponding sines and cosines to obtain the following quantities of the differential equations:

$$-g\,d\,G \sin (G + a) + dg \cos (G + a)$$

$$[-h\,d\,H \sin (H + a) + dh \cos (H + a)] \sin \delta$$

$$di \cos \delta$$

It should be stated that $d\,G$ and $d\,H$ are first reduced to linear quantities. The sum of this last column omitting

the two middle values, gives the quantity to be applied to the reduction for January 20th to obtain that for January 25th, and will in most cases be found to be correct within one or two hundredths of a second.

The method by differences is considered to be a saving of about one-half the usual time, besides being very much easier, as many as thirty pairs being computed for two dates, in about seven hours, by a person familiar with the method. After the computation of the first date, the corrections to be applied to these to get those for the second date were found in two hours. But in order to work advantageously each step is taken up systematically and carried through the entire number of pairs, and often two steps may be carried along simultaneously where the multipliers are single or when the tables may be kept open two places at once. Care should be exercised to avoid using more places than are necessary. For example, in the direct computation for the first date, three figures are sufficient, except where h enters. It is not considered essential to secure exactly the fourth place here, but it may be done with Crelle's tables mentally, and with very little labor, by taking the nearest unit in the third place and applying to the product the algebraic sum of the unit's place by the thousandths, one or two places at most only being considered. In forming the products for the differences two places generally need only be retained.

The difference of $0''.03$ between that calculated rigorously for January 25th and that derived by the formulæ is due to the fact that the differences have been treated as differentials and not as finite differences. The neglected product, $dh, d H, \sin (H + \alpha)$, does not amount to more than $0'.003$ and need not be regarded when $\sin \delta$ is as much as 0·90, for, as a rule, stars are not observed above 65° declination.

If we had treated the difference in the cosine of $(H + \alpha)$ as a finite difference, using the formula,

$$- 2 \sin (\gamma + \tfrac{1}{2} \Delta\gamma) \sin \tfrac{1}{2} \Delta\gamma$$

instead of $- \sin \gamma \, d \gamma$, the agreement would, of course, have

been perfect; the essential points in the method being that the differences are considered as differentials, and the term involving the product of the differences is neglected.

It might be supposed that if we have a difference of 0″·03 in the position of a star for a difference in H of, say, 5°, that this discrepancy would amount to a quantity entirely inadmissible in the case of G, in May, 1890, where the difference is upwards of 30°; but, since, when these excessive changes in G occur, B is necessarily quite small, because the longitude of the moon's ascending node is near 90°, the discrepancy between the values of $g \cos (G + a)$, calculated by the differential formulæ, and those by actual multiplication, does not much exceed that in the present case; in fact, they only differ by 0″·05. Indeed, the large discrepancy in the present case is due to the fact that the error committed in neglecting the formula for finite differences must be multiplied by h, which increases it twenty-fold. g in the extreme case of 1890 is 0″·8, hence only $\frac{1}{25}$th of h for this case. But the discrepancy for the values of May, 1890, comes from another source, viz: From the product of the two differentials dg and $d\,G$, and even then will only occur for a few pairs where $(G + a)$ is near 90°, and where the sine is large. It will be noticed that, assuming a value for $(G + a)$, which gives the most rapid change in the cosine, also gives a large value for the sine, and hence increases the value of the term $dg \sin (G + a)\, d\,G$, there is a combination of circumstances tending to increase the discrepancy to 0″·08. This must be regarded, therefore, as a very exceptional case. When we consider that the probable errors of the declinations of the individual stars are several times as large, this may be neglected.

In general, the errors introduced by this method are quite insignificant, even admitting the declinations to be absolutely true, for errors of observation will much exceed these. Besides, for the extreme case of 1890, we have assumed a value for $(G + a)$, which would give the greatest possible change in the cosine for the change in G under consideration; that is, a value extending from about 85° to 105°. Moreover, since this term depends on the star's right

ascension, for any station this extreme case would only apply to a few pairs which involved values of $(G + a)$ passing through the points 90° or 270°; no night's work ever lasting long enough to pass through or even near them both.

When the observations do not extend beyond five days, the last date is derived from the first by differences. For work extending over a period from five to fifteen days, the middle date is actually computed, and the first and last obtained by differences. Where on account of bad weather observations are very much scattered, it is better to make separate computations for each date. Under ordinary circumstances, three successive nights are all that are required, which involves differences in the star numbers for only two days. In this case, the result by differences will be found to be identical with that of a rigorous calculation. For where $d\,G$ and $d\,H$ are about 2°, and $d\,g$ and $d\,h$ one or two-tenths, their product does not affect the hundredths place; and the change in the cosine of an arc, whether computed as a differential or a finite difference, is practically the same for differences of arc of 2°, the discrepancy never amounting to a unit in the hundredths place.

Assuming the probable error of observation to be 0″·50, which is about the usual experience, and the probable error of one declination to be 0″·30, we find the following relations between the number of nights, number of pairs, and the probable error of the mean result.

No. of Nights.	Number of Pairs.					
	5	10	15	20	25	30
	Resulting Probable Error of Mean Result.					
	″	″	″	″	″	″
3	0·17	0·12	0·09	0·08	0·07	0·07
5	·15	·10	·08	·07	·06	·06
7	·13	·09	·07	·06	·06	·05

SPACING THE ELLIPSE.

By GEORGE B. GRANT, Lexington, Mass.

I have frequently found it necessary in the course of my business, which is specially confined to the making and cutting of gear wheels, to cut the teeth of an elliptic gear. Although I have always used the greatest care and have had the advantage of experience and the best of tools, I have seldom succeeded in actually cutting such a gear to the combined satisfaction of myself and my customer, while, from a business point of view, nothing but a price that is almost prohibitory will make an order for such a gear in any way desirable.

The difficulty has been in the spacing of the curve so that the teeth could be evenly placed and give a smooth action. The usual method is to draw the curve and space it with the dividers, step by step, and, although the process is simple enough to describe, it is exceedingly clumsy, tedious, and inaccurate in operation.

Realizing that the only impediment to the general use of the elliptic gear for quick return motions and for other variations of speed, in positions where its simplicity and its positive action makes it unrivalled by any other mechanical movement, was the present expense of producing it and the poverty of the usual result, I undertook the construction of a special machine for the purpose. I had no difficulty in designing a machine that would keep the cutter accurately in the elliptic path, but it was only after a long search and many experiments that I found a device for spacing the elliptic outline that would serve that purpose even approximately.

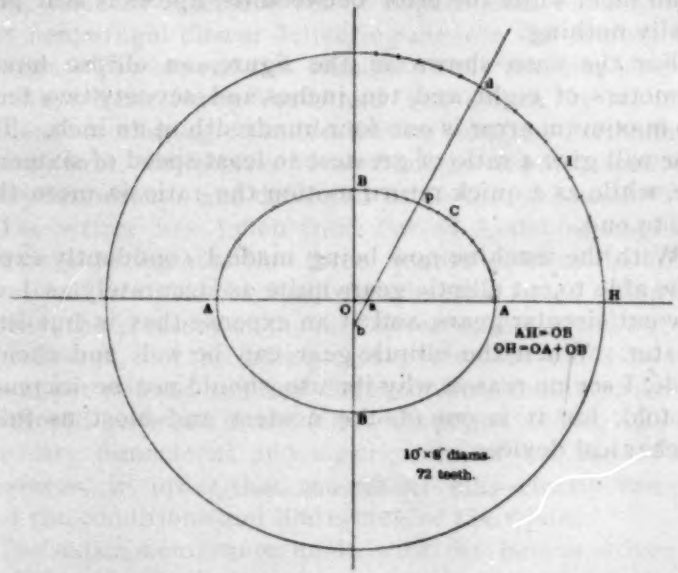
The result of my search was the device here described, and it can be easily applied with a degree of accuracy that is far beyond the requirements of actual practice.

In the figure, suppose the ellipse to be described on the principle of the common trammel, the two pins *a* and *b*

being confined to the two lines *OA* and *OB*, while the point *p* draws the curve.

Draw an index circle, *I*, from the centre, *O*, of the ellipse, and let its radius, *OH*, be equal to the sum of the radii, *OA* and *OB*, of the ellipse. Then, if the line, *b a p*, extended, accurately spaces the index circle at *d*, it will also space the ellipse with an accuracy that is practically perfect for cases that are in use for elliptic gears.

To show the accuracy of the device take a very common example. Given, an ellipse with a major diameter of ten



inches and a minor diameter of nine inches, with seventy-two teeth. This ellipse, used as a quick return motion, would give a ratio of slow stroke to quick return stroke of more than three to one, and when used for variation of speed, would give a variation of fastest speed to slowest speed of about six and one-half to one. It is, therefore, a practical example, elliptic gears being generally much more nearly circular.

For this example the errors in spacing, although theoretically present, are practically nothing. The chord of the

tooth space at the major apex *A* is ·41433 inch, while that at the minor apex *B* is ·41441 inch, giving an error of about one twelve-thousandth of an inch. The greatest error is on the quarter, at *C*, and not at the apices, but the difference between the greatest and the least tooth spaces is not over one two-thousandth of an inch.

If we take an extreme case we shall find a greater error. For diameters of twelve and six inches and seventy-two teeth, which would be wholly useless for practical purposes, the greatest error is still very small, not over one-seventieth of an inch, while the error between the apices is still practically nothing.

For the case shown in the figure, an ellipse having diameters of eight and ten inches and seventy-two teeth, the maximum error is one four-hundredth of an inch. This gear will give a ratio of greatest to least speed of sixteen to one, while as a quick return motion the ratio is more than five to one.

With the machine now being made I confidently expect to be able to cut elliptic gears quite as accurately as I can now cut circular gears, and at an expense that is but little greater. When the elliptic gear can be well and cheaply made, I see no reason why its use should not be increased ten-fold, for it is one of the neatest and most useful of mechanical devices.

AN INVESTIGATION OF SOME EXPERIMENTS ON A CENTRIFUGAL BLOWER DELIVERING AIR INTO THE ATMOSPHERE AT LARGE.

By Chief Engineer Isherwood, U. S. Navy.

In the month of July, 1888, Passed Assistant Engineer James J. Barry, of the Corps of United States Naval Engineers, made an extensive set of experiments on a Sturtevant centrifugal blower delivering air into the atmosphere at large. The blower was situated in the machine shop of the New York Navy Yard, and was driven by an independent oscillating non-condensing engine articulated directly to it. It received its air from the still atmosphere of a very large room, and delivered its air into the same.

The writer has taken from Passed Assistant Engineer Barry's experiments, the three quantities that the latter directly determined for each experimental speed of blower, namely, the pressure of the air delivered, the velocity of the air delivered, and the number of revolutions made by the blower per minute, and has deduced from them the results which will be found in the following pages, adding also the necessary dimensions and descriptions of the blower and apparatus, in order that the reader may clearly comprehend the conditions and limitations of the trials.

The experiments were made with the blower driven at velocities varying from 1,250 to 1,950 revolutions per minute. They serve within their limits to determine the velocity in feet per minute with which, at different rotary speeds of the blower, the air was discharged into the atmosphere. Also, the volume and weight of air delivered into the atmosphere per revolution of the blower, and whether that volume and weight were affected by the rotary speed of the blower, and if so, in what degree. Also, to ascertain the pressures produced by the impacts of the discharged air at different velocities, as shown by the respective heights of the columns of water equilibrated by these impacts and measured between

the water surfaces in the two legs of a U-tube. Also, to determine the law connecting these heights of water columns with the velocities of air producing them. Also, to determine the relation between the velocity of the centre of the surface of the fans or blades of the blower and the corresponding velocity of air discharge. Finally, to determine the powers expended in producing the air compressions and discharges at different rotary speeds of the blower.

The oscillating steam cylinder driving the blower exhausted into the atmosphere, and its piston made one double stroke to each revolution of the blower. The indicated pressure on this piston could not be ascertained, owing to its great reciprocating speed. The diameter of the cylinder was $2\frac{1}{8}$ inches; the diameter of the piston rod on one side of the piston was $\frac{7}{16}$ inch in diameter, and on the other side $\frac{13}{32}$ inch in diameter; the stroke of the piston was $1\frac{1}{4}$ inches. The mean net area of the piston, exclusive of the cross areas of its piston rods, was 3·4065 square inches; and the space displacement of the piston per stroke, was 4·2581 cubic inches.

The centrifugal blower consisted of six radial flat fans or blades equispaced about their axis and revolving in a cast-iron case, with a side clearance of about $\frac{5}{32}$ of an inch wide. The outside diameter of the fans was $12\frac{1}{4}$ inches, and their inside diameter was seven inches. Each fan was connected to the shaft by an arm averaging $\frac{3}{4}$-inch in width. The radial depth of the fan was therefore

$$\left(\frac{12{\cdot}5 - 7{\cdot}0}{2} = \right) 2{\cdot}75 \text{ inches.}$$

Each fan was a regular trapezoid; its breadth at its outer edge was $3\frac{3}{16}$ inches, and at its inner edge $3\frac{1}{8}$ inches, making its area

$$\left(\frac{3\frac{3}{16} + 3\frac{1}{8}}{2} \times 2{\cdot}75 = \right) 9{\cdot}3671875 \text{ square inches.}$$

The aggregate area of the six fans was 56·203125 square

inches. The circumference of the centre of surface of the fans was 2·5387 feet.

The vertical inside diameter of the case was 19·75 inches; the horizontal inside diameter of the case was $18\frac{1}{16}$ inches; the inside width of the case was $5\frac{1}{4}$ inches, with an inner reinforce or raised edge around the seven-inches diameter opening. The outlet for the air delivery was cylindrical, $6\frac{3}{16}$ inches in diameter, and 10 inches in length measured on its axis to the intersection of the same with the inside circumference of the case. The area of the air delivery was 30·069 square inches or 0·2088125 square foot.

The axis of the fans was not coincident with the axis of the case. The distance between the outer periphery of the fans and the inside of the case on the vertical diameter of the fans was 2·75 inches at top and 4·50 inches at bottom. The distance between the outer periphery of the fans and the inside of the case on the horizontal diameter of the fans was $2\frac{1}{16}$ inches at the air-delivery side of the case and $3\frac{1}{2}$ inches at the opposite side. The flat sides of the case were parallel and connected by a segmental curve of $3\frac{3}{32}$ inches radius. The cylindrical air discharge was horizontal and its bottom was tangent to the bottom of the case. In each flat side of the case was a circular opening of seven inches diameter, the one opposite the other; the centres of both were coincident with the axis of the fan shaft. These openings admitted air to both sides of the fan. The fan shaft was one inch in diameter and extended entirely through the case, the journals being held in pillow blocks outside the case. Where the fan shaft passed through the air-receiving openings of the case, it was sheathed by couplings of $1\frac{1}{2}$ inches outside diameter, deducting the cross area of which, and the area of a half-inch wide rib extending downwards from it, from the area of the seven-inches diameter air opening, there remains for the aggregate effective area of the two openings 70·685 square inches, or 2·35 times the area of the air delivery.

The side edges of the fans, on each side of the blower, were joined together by a ring of sheet iron of the radial depth of the fans, and the latter were riveted by their side

edges to these two rings, so that the air which had once entered between any two fans could not escape sideways, but had to be delivered at the outer periphery of the fans.

Nine sets of experiments were made with different rotary speeds of blower. The increase in the number of revolutions made per minute by the blower for each succeeding set of experiments, was by as nearly equal increments as possible. Each set consisted of twelve observations of each quantity, and the observations were taken at five minutes intervals, so that each set of experiments occupied one hour.

The velocity of the air in feet per minute leaving the blower, was obtained from a very sensitive helicoidal anemometer, well placed within the cylinder for the air-delivery and resting on the lower side of that cylinder, so that the axis of the anemometer was about midway between the axis of the cylinder and the side of the latter.

The number of revolutions made by the blower per minute, was obtained from a mechanical counter applied directly to the end of the fan-shaft.

The pressure corresponding to the impact of the air being discharged through the horizontal cylindrical air-delivery, was obtained by directly measuring the height between the water levels in the two vertical legs of an open ended glass U-tube, the ends of which were bent at right angles to the legs. One end of the tube was inserted horizontally well into the cylindrical air-delivery about midway between the axis and the circumference of the latter, while the other end remained horizontally in the atmosphere. The temperature of the atmosphere being 75° F., each inch high of water column was equivalent to a pressure of 0·036 pound per square inch.

The observations of the three quantities were made as nearly simultaneously as possible, the engine running at a uniform speed.

The pressure due to the impact of the discharged air varied, during the experiments, from 0·66 inch to 1·60 inches high of water column above the atmospheric pressure, equivalent to 0·02376 and 0·05760 pound per square inch.

A collation of all the experiments showed that this pressure was almost exactly in the ratio of the square of the velocity with which the air was discharged. The experimental pressures denoted by the U-tube were probably a little too small, due doubtless to the adhesion of the water to the sides of the U-tube. When the impact pressure is as small as in the case of these experiments, the pressure equilibrating the water adhesion to the sides of the tube may sensibly affect the absolute but not the relative results. The experimental determination of the increase of the impact pressure of the moving air, in the ratio of the square of the velocity of the air, is in conformity with the theoretical deduction; twice the mass of air in equal time moving with twice the velocity, being brought to rest in the U-tube, when the velocity of the discharged air is doubled, quadruples the resulting pressure.

The velocity in feet per minute of the discharged air, was in the direct ratio of the rotary speed of the blower, showing that the quantity of air delivered per revolution of the blower was the same at all rotary speeds of the blower within the experimental limits. The quotient of the division of the velocity of the discharged air in feet per minute, by the number of revolutions made by the blower in the same time, is a constant number.

As the rotary speed of the blower is in the direct ratio of the velocity of the air discharged from it, and as the impact pressure produced in the U-tube is in the ratio of the square of the velocity of this discharged air, the rotary speed of the blower is in the ratio of the square root of the corresponding impact pressure. Of course, the velocity of the discharged air is also in the ratio of the square root of the corresponding impact pressure.

A collation of all the experiments shows that the velocity of the discharged air, as measured by the anemometer, was 4,092 feet per minute, when the blower made 1,585 revolutions per minute, the impact pressure in the U-tube being at the same time equilibrated by a column of water one inch high at the temperature of 75° F., equivalent to a pressure of 0·036 pound per square inch. From these

quantities, the corresponding similar ones can be calculated according to the above proportions for any other speed of blower, velocity of discharged air, or pressure in the U-tube.

The impact pressure in the U-tube is exactly the pressure within the blower-case producing the velocity of the discharged air. Whatever pressure put this air in motion with any velocity whatever, that air will exactly reproduce when brought to a state of rest. This is a very important fact and shows that the air pressure within the case at the entrance of the horizontal cylinder discharging the air was exactly equal to the pressure denoted by the water column supported in the U-tube by the impact of the air.

The velocity with which the air should be discharged into the atmosphere under the pressure of 0·036 pound per square inch above the atmosphere, can be calculated as follows and compared with the experimental result. Assuming the air employed in these experiments to have been three-fourths saturated with aqueous vapor, to have had the temperature of 75° F., and to have been under the standard atmospheric pressure of 14·68757 pounds per square inch, it would weigh 0·07360785 pound per cubic foot, and there results for the velocity of such air into vacuo

$$\left(\sqrt{\frac{14\,68757 \times 144}{0{\cdot}07360785}} \times 64{\cdot}316078 = \right) 1359{\cdot}7379 \text{ feet per second.}$$

The square root of the pressure 14·68757 pounds per square inch is 3·8324, and the square root of the pressure 0·036 pound per square inch above the atmosphere in the U-tube is 0·19, therefore the velocity of the discharging air should have been (3·8324 : 0·19 :: 1359·7379 :) 67·4121 feet per second. Experimentally the velocity was

$$\left(\frac{4092}{60} = \right) 68{\cdot}7000 \text{ feet per second,}$$

a remarkably close correspondence, proving the accuracy of the experiments, and the correctness of the assumptions on which the calculation was made.

The number of cubic feet of air delivered into the atmosphere by the blower per minute under the above conditions, allowing 0·82 for the coëfficient of discharge through the cylindrical air-delivery was

$$\left(\frac{30{\cdot}069 \times 4092 \times 0{\cdot}82}{144} =\right) 700{\cdot}658,$$

or

$$\left(\frac{700{\cdot}658}{1585} =\right) 0{\cdot}44205552 \text{ cubic foot per revolution}$$

of the blower. These figures are equivalent to (700·658 × 0·07360785 =) 51·572529 pounds of air delivered by the blower per minute, or to

$$\left(\frac{51{\cdot}572529}{1585} =\right) 0{\cdot}032537873 \text{ pound}$$

delivered per revolution of the blower.

As each cubic foot of air of the above temperature and proportion of aqueous vapor contains 0·016862154725 pound of oxygen, the blower delivered (700·658 × 0·016862154725 =) 11·814603605 pounds of oxygen per minute, or 0·007454009 pound per revolution.

The circular velocity of the centre of surface of the fans of the blower, was (2·5387 × 1585 =) 4023·8395 feet per minute. It should have been the same as the velocity of the discharge; namely, 4,092 feet per minute, the difference being due to errors of observation and of instruments.

As the aggregate fan surface of 56·203125 square inches acted against the air pressure of 0·036 pound per square inch above the atmospheric pressure, the blower performed (56·203125 × 0·036 × 4023·8395 =) 8141·484758344 foot-pounds of work on the air per minute, equivalent to 0·2467117 horse-power. In doing this work, however, the power expended by the engine in driving the blower may be considerably greater than the above, if the pressure of the inflowing air against the back of the fans were less than the quiescent atmospheric pressure, consequently the indicated horse-power developed by the engine cannot be deduced from the horse-power exerted by the fans in compressing the air against which they act. All that can be

inferred is that the above 0·2467117 horse-power exerted by the fans is a minimum to which about one-fifth must be added for the engine frictions, making the indicated horse-power not less than about 0·3, provided the atmospheric pressure followed with its full effect against the back of the fans.

The area for the delivery of the air was 30·069 square inches; the velocity with which the air was delivered was 4,092 feet per minute; and the pressure causing this velocity was 0·036 pound per square inch above the atmospheric pressure; hence, the work done upon the outgoing air was (30·069 × 0·036 × 4092 =) 4429·524528 foot-pounds, or

$$\left(\frac{4429{\cdot}524528 \times 100}{8141{\cdot}484758344} =\right) 54{\cdot}4071 \text{ per centum}$$

of the work done by the fans upon the inflowing air. A considerable portion of the difference is doubtless due to regurgitation of the air compressed in the case, through the $\frac{3}{32}$-inch wide clearance space between the blower and the side of the case, equal in the aggregate to (3·1416 × 7 × 0·1875 =) 4·12335 square inches. Also, to loss of *vis viva* by the air once put in motion by the fans, and then brought to rest in the case by opposing collisions, and requiring to be again put in motion before escaping.

If the quantity of air lost by regurgitation be taken to be in the direct proportion of the 4·12335 square inches of opening between the sides of the blower and the flat sides of its case, to the 30·069 square inches of opening for delivering the air, which assumption is warranted because the pressures producing the regurgitation, and the air-delivery are equal, then

$$\left(\frac{4{\cdot}12335 \times 100}{4{\cdot}12335 + 30{\cdot}069} =\right) 12{\cdot}0593 \text{ per centum}$$

of the air acted upon by the blower was thus lost by a mere mechanical, but inevitable imperfection of the blower fitting. Adding these 12·0593 per centum to the above 54·4071 per centum, there results 66·4664 per centum realized of the work done by the fans on the air, or, say, two-thirds, leaving one-third of the air acted upon by the fans, as the

fraction of that air brought to rest in the blower-case after having been put in motion by the fans. This one-third of the work done reappears as heat in the air, and is promptly lost by radiation. Two-thirds, then, are the true efficiency of the blower as a furnisher of air, philosophically considered, supposing the inflowing air to act with atmospheric pressure against the back of the fans. The practical efficiency, however, is only (54·4071 × 0·82 =) 44·6138 per centum under the same conditions, the 0·82 being the coëfficient of reduction for the delivery of the delivering cylinder; and if the power applied to the blower-shaft by the steam cylinder be taken as unity, the practical coëfficient of the blower cannot exceed thirty per centum.

The continually changing air between the periphery of the blower and the case, may be considered to be compressed to the uniform pressure of 0·036 pound per square inch above the atmosphere by the centrifugal action of the fans, when the latter made 1,585 revolutions per minute.

The number of foot-pounds of work done by the outflowing air may be ascertained by using the data in another manner. The weight of air delivered per minute was 51·572529 pounds, and with the velocity of 4,092 feet per minute. The height through which a body must fall to obtain that velocity is 71·9443 feet. Now 71·9443 × 51·572529 = 3710·349498, which divided by the co-efficient of discharge 0·82 gives 4524·8164 as the number of foot-pounds of work done per minute by the outflowing air. This result is very nearly the same as the above 4429·5245 foot-pounds determined from the pressure and velocity of that air, and using of course, the entire air-delivery orifice.

The lacunes in the experimental data are the indicated power developed by the small steam cylinder driving the blower, the velocity of the air flowing into each side of the case, the pressure of the air within the case between the periphery of the blower and the circular side of the case, and the temperature of this compressed air. Nevertheless, so little is the experimental knowledge possessed on the subject of centrifugal air blowers, and so important is such knowledge when their extensive use in

the industrial arts is considered, that the experiments of Past Assistant Engineer Barry, made with the very limited means at his command, have great value.

The experiments in question, made with an apparatus of the kind and dimensions, and in the manner, and within the limits described, allow the following generalizations to be drawn.

(1) The quantity of the same air, volume and weight, delivered by the blower per revolution, is constant, let the number of revolutions made in a given time be what it may.

(2) The velocity of the air delivered, is in the direct ratio of the number of revolutions made by the blower in a given time.

(3) The velocity of the centre of the surface of the fans, is the same as the velocity with which the air is delivered.

(4) For any number of revolutions of the blower in a given time, the air pressure above the pressure of the atmosphere, reacting against the surface of the fans, and existing in the annular space between the periphery of the fans and the circular side of the blower-case, and causing the velocity with which the air is delivered, is equal.

(5) The velocity with which the air is delivered at the outer end of the delivering cylinder is the velocity due to the excess of the air pressure at the inner end of the delivering cylinder above the atmospheric pressure. This excess of pressure being known, the velocity can be calculated, and, *vice versa*, the velocity being known, this excess of pressure can be calculated.

(6) The velocity with which the air is delivered at the outer end of the delivering cylinder is in the ratio of the square root of the above excess of pressure. Inversely, the above excess of pressure is in the ratio of the square of the number of revolutions made by the blower in a given time.

(7) When the velocity of the air is suddenly extinguished, the same excess of pressure above the atmosphere is reproduced that caused the velocity.

(8) The work done by the fans upon the inflowing air is measured by the above excess of pressure per square inch, multiplied by the aggregate area of the fans in square

inches, and by the velocity of the centre of surface of the fans in feet per minute. This, however, is by no means the work done by a motor driving the blower, as such work must include, additionally, the difference between the quiescent atmospheric pressure and the pressure of the inflowing air against the back of the fans, and the friction of the motor.

(9) The work done by the outflowing air, is measured by the above excess of pressure per square inch, multiplied by the cross area of the delivering cylinder in square inches, and by the velocity of the outflowing air in feet per minute.

(10) As the velocity of the centre of surface of the fans is the same as the velocity of the outflowing air, and as the pressure above the atmospheric pressure produced by the fans upon the air is the same as the pressure producing the velocity of the outflowing air, the work done by the fans on the air, and the work done by the outflowing air, are in the direct ratio of the aggregate area of the fans to the cross area of the delivering cylinder.

(11) The number of cubic feet of air delivered per minute is measured by the cross area of the delivering cylinder in square feet multiplied by the velocity of the air issuing from that cylinder in feet per minute, and by 0·82 for the coëfficient of discharge.

(12) Of the entire quantity of air entering the blower and put in motion by the fans, one-third is first brought to rest within the blower-case, after which it is again set in motion by the fans with its original velocity.

(13) The theoretical coëfficient of the blower as a furnisher of air is two-thirds, including the air leakage; its practical coëfficient does not exceed thirty per centum.

(14) The resistance of the blower is as the square of the number of revolutions made by it in a given time. The power required to drive the blower, irrespective of the motor, is as the cube of the number of revolutions made by it in a given time.

OBITUARY.

WILLIAM PETTIT.

WM. PETTIT, deceased upon the eighth day of June, 1888, was one of the members of longest connection with the FRANKLIN INSTITUTE, having joined it in the year 1837. He was born in the year 1808, in Philadelphia County, near the village of Falls of Schuylkill, at which place he received a common-school education.

At a suitable age he entered, as one of their first apprentices, the workshops of Messrs. Mason & Baldwin, who, at that time, were engaged in the manufacture of rolls for calico printers and small machinery of a general kind. From the commencement of his apprenticeship he remained throughout the several changes of partners and of location, made by Mr. Baldwin to obtain enlarged facilities, until his final establishment at Broad and Willow Streets, and so grew up with the establishments in which he spent his business life, until an accident to his person partially incapacitated him from active pursuits.

At an early period of their connection he had won the confidence of his employer by close attention to duties, and was advanced to positions of responsibility to which he was fitted by skill and natural ability. Mechanical drawing was with him a self-acquired branch of the machinists' art, and for many years he was the chief draughtsman of the works.

During an early period of his service (1831) there was made, from descriptions of the English machines, and exhibited in motion under Mr. PETTIT's charge, at Peale's Museum, in this city, a working model of a locomotive engine, which, from its novelty, was an attractive object to the public.

The first practical locomotive of American construction, in which Mr. PETTIT took part, was built soon after and put upon the road, and others followed a few years later. A pair of horizontal engines were built from Mr. PETTIT's drawings and placed in a boat intended for breaking up the ice in the Delaware River to permit navigation, and for towing during the winter season.

A satisfactory trial took place in January, 1838, under Mr. PETTIT's charge. They were the most powerful of their kind at that time, and are so justly proportioned and made to endure extremely hard service that they are still fitted for work at the present time, after a life of half a century's duration.

Mr. PETTIT was a born mechanic and possessed the excellent judgment and knowledge of detail so necessary to the full equipment of the mechanical engineer, and withal was modest and unassuming. He was one of the few to whom the country is indebted for their labors in developing from its initial state the locomotive engine.*

WASHINGTON JONES,
SAMUEL R. MARSHALL.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS.

HEXAMER'S FIRE EXTINGUISHER FOR MALT MILLS.

[No. 1380.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 2, 1887.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred, for examination,

HEXAMER'S FIRE EXTINGUISHER FOR MALT MILLS,

Respectfully Report: That the device consists of the application of steam under pressure as a fire extinguishing agent, which is directed through a pipe into the mill box. A stop valve outside of the box is operated by a lever held up by a weight, the weight being held suspended by a wedge or pin. To the wedge is attached a chain which is connected to a door on the side of the mill box. The force of the explosion blows open the door, which releases the wedge, causing the weight and lever attached to fall, which in turn

* Presented at the Stated Meeting of March 20, 1889. Accepted and referred for publication.

opens the valve, letting in the steam to the mill box and up through the conveyors. To check the downward passage of the fire, a set gauge controls the flow of grain in quantity, causing a bank of the material always to be in the hopper, thus resisting the force of the explosion or passage of fire downward.

The committee were aided in their investigation by being afforded an opportunity of seeing the device as attached to several breweries in our city, together with the report of successful working of the appliance when called upon.

A full description of the apparatus, with copy of letters-patent, accompanies the report.

The committee recommend the award of the JOHN SCOTT MEDAL.

[Signed.] WM. MCDEVITT,
SAMUEL H. NEEDLES,
J. M. EMANUEL.

Adopted October 5, 1887.

[Signed.] WM. D. MARKS, *Chairman.*

CONTRIBUTIONS TO THE KNOWLEDGE OF THE SUGAR GROUP. E. Fischer and J. Tafel. *Berichte*, **22**, 97 (From the *Zeit. f. ang. Chemie*).—The authors have prepared α-acrose, the first synthetic representative of the group of sugars belonging to the hexan series. α-acrose ferments under the influence of yeast and gives all the characteristic reactions of the natural sugars, dextrose, lævulose and galactose. It does not, however, affect polarized light. It would seem probable that α-acrose contains a normal carbon chain formed by the condensation of two molecules of glycerin aldehyde. This synthesis is the first successful step towards the artificial preparation of the more important sugars. The authors are endeavoring to obtain an optically active sugar from α-acrose. S. C. H.

ON SOME NEW TESTS FOR TANNIC AND GALLIC ACIDS. By S. G. Rawson (*Chemical News*, **59**, 52).—If to a solution of tannic acid, containing one part in 20,000 parts of water, a mixture of ammonium hydroxide and ammonium chloride be so added that the solutions do not mix, a white precipitate will be formed at the surface of contact. One part in 50,000 parts of water may be detected, if great care be taken. Gallic acid yields no precipitate under like conditions, but at the surface of contact a greenish ring may be observed. This coloration may be seen in solutions containing one part in 100,000 parts of water. L. B. H.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, March 19, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 19, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: Dr. L. B. Hall, Dr. H. W. Jayne, Dr. E. H. Keiser, Dr. H. F. Keller, Dr. Wm. H. Wahl, Prof. R. L. Chase. Prof. E. F. Smith, Dr. S. C. Hooker, Messrs. Reuben Haines, T. C. Palmer, W. H. Bower, Thos. N. Newbold, C. J. Semper, Jacob Lichenheim, W. L. Rowland, F. Lynwood Garrison, W. W. McFarlan, Dr. W. C. Day, and three visitors.

The revised By-Laws, which had been laid over at the last meeting, were adopted without alteration.

The Treasurer reported that, in accordance with a recommendation made at the previous meeting, he had notified certain delinquent members of their arrears; as a result arrears were made good in one case, while in four others they were not; the Section voted that the names of the four delinquent members be dropped from the list.

Mr. F. Lynwood Garrison was elected a member of the Section.

In accordance with the new By-Laws, Section VII, the President appointed Messrs. W. W. McFarlan, W. H. Bower and the Secretary members of the committee to transact the financial business of the Section.

Upon nomination, in accordance with the revised By-Laws, Section II, the following gentlemen were elected members of the "Committee on Admissions": Dr. L. B. Hall, Dr. E. F. Smith, Dr. H. F. Keller, Dr. Wm. H. Wahl, Dr. S. C. Hooker, Mr. W. L. Rowland and Mr. C. J. Semper.

At the close of the meeting the Committee on Admissions notified the Secretary that Mr. Lee K. Frankel and Mr. A. W. Allen had been elected members of the Section.

Upon the motion of Dr. Jayne, it was voted that 250 extra copies of the revised By-Laws be printed for the future use of the Section.

Mr. T. C. Palmer then read his paper on "The Testing of Logwood Extracts."

Mr. Palmer remarked that he wished to call particular attention to the statement in his paper, that under the conditions of the test for strength of logwood extracts, with which the paper dealt, the compounds of tannin and copper oxide were nearly or quite colorless. This difference in behavior between tannin and hæmatine was the more remarkable, since in many other respects the latter acts precisely as a tannin. This is even true with respect to its action on hide powder. An attempt to estimate the tannin in a pure extract of logwood, by means of filtration through powdered hide, had resulted in an apparent showing of twenty per cent. of tannin, which loss was evidently due to an absorption of the hæmatine by the hide. In fact, the attraction of the hide for the coloring matter is quite as strong as it is for tannin. The speaker here showed a column of hide powder deeply colored by the passage through it of a very dilute clear solution of logwood.

Mr. Palmer also made some preliminary remarks on the faultiness of the tannin process of Hammer, as modified by Procter, giving data that show the amount of soluble matter in hide powder to depend very largely on the time the water is in contact with the hide, *i. e.*, in the rate of percolation. The hide powder, made by Schuchardt, gave to water an extract that left a residue on evaporation, ranging in amount, easily oxidizable, soluble in water, and with many of the reactions of the so-called coriin. The one fact above all that showed the faultiness of the process of Procter was that this residue, when redissolved in water, *was precipitated on addition of tannin solution.* Thus while the amount soluble in water could be only roughly estimated, the amount dissolved out by the tannin solution was simply unknowable, since at the top of the column, where the tannin is in abundance, there would be no dissolving out of the coriin, but as the liquor trickled down, losing tannin, it would dissolve more and more. The speaker stated that he expected shortly to bring before the Section his method of obviating this difficulty, retaining hide powder as the absorbent of tannin, but obtaining the tannin strength of the solution before and after filtration by an expedient that rendered evaporation of solutions or specific gravity determinations unnecessary.

Dr. S. C. Hooker's paper, "On a Rapid Colorimetric Method of Accurately Determining Nitrates in Potable Waters," was read by title.

Dr. E. H. Keiser read a paper "On the Redetermination of the Atomic Weight of Palladium." The following is an abstract of this paper, which was listened to with much interest, and was afterwards discussed by a number of the members present:

The atomic weight of palladium has not been determined very carefully. The only data for the calculation of this constant, at the present time, are two analyses of the double chloride of palladium and potassium, made by Berzelius in 1828. These two analyses do not agree very well. The first one gives 105·7, and the second one 106·2 for the atomic weight of palladium.

For the purpose of redetermining this atomic weight, metallic palladium in the form of foil was dissolved in aqua regia and the solution evaporated to dryness. The palladium chloride was then dissolved in dilute hydrochloric

acid and the solution was filtered. Ammonia was added to the filtrate until the precipitate, which at first formed, was redissolved. After filtering the solution again, to remove any traces of ferric hydroxide, the filtrate was saturated with hydrochloric acid gas. The palladium is thus precipitated as palladium-diammonium chloride, $Pd(NH_3Cl)_2$, a yellow crystalline compound which is insoluble in water and acids, but which is readily soluble in dilute ammonia.

The yellow precipitate was redissolved in dilute ammonia, and the solution was filtered. If any rhodium had been present in the original sample of metallic palladium, it would have been separated by this process, because the rhodium diammonium chloride is insoluble in dilute ammonia. The filtrate was thereupon treated with hydrochloric acid and the palladium diammonium chloride, thus precipitated, was thoroughly washed with distilled water, until all ammonium chloride was removed. The compound was carefully dried over sulphuric acid in a partial vacuum.

The compound was analyzed by weighing off portions in platinum boats and heating up in a current of pure hydrogen. At a low temperature the yellow compound absorbs hydrogen, metallic palladium and ammonium chloride being formed.

$$Pd(NH_3Cl)_2 + H_2 = Pd + 2\,NH_4Cl.$$

On raising the heat, the ammonium chloride is completely volatilized and spongy palladium remains behind. After the boat and its contents had cooled off somewhat, the hydrogen stream was replaced by one of dry air, and the boat was allowed to cool off completely in the air. By this means i was possible to avoid the retention of hydrogen by the palladium, and as the hydrogen stream was not displaced by air until the temperature of the palladium had fallen considerably below a low red heat, it was not possible that palladium oxide should have been formed.

DETERMINATION OF ATOMIC WEIGHT OF PALLADIUM.

I.—By ignition of $PdN_2H_4Cl_2$ in current of hydrogen.

NUMBER.	Weight of Substance	Weight of Palladium	Atomic Weight.
1,	·83260	·44965	106·459
2,	1·72635	·93094	106·410
3,	1·40280	·76670	106·355
4,	1·57940	·85562	106·342
5,	1·80805	·97650	106·328
6,	1·48065	·79570	106·292
7,	1·56015	·84585	106·322
8,	1·82658	·98203	106·317
9,	2·40125	1·29970	106·355
10,	1·10400	·59629	106·409
11,	·93310	·50010	106·366
TOTAL,	16·74583	8·43606	[106·3520]

Atomic weight = 106·35 H = 1· Maximum, = 106·459
N = 14·01 Minimum, = 106·292
Cl = 35·37 Difference, = ·167
Atomic weight = 106·62, when o = 16.

The foregoing table contains the results of all of the determinations that were made.

The investigation will be continued. It is intended to make a series of determinations by means of other palladium compounds.

Prof. E. F. Smith followed with two interesting papers, the first of which was entitled, "Oxidations by Means of the Electric Current," and the second, "On the Compound $C_{21}Cl_{25}$." Both papers were referred for publication in the JOURNAL OF THE INSTITUTE.

In connection with the use of the electric current in determining and separating metals, it occurred to the author that the oxidizing power of the current might be utilized to convert sulphur and other elements into higher oxides, thus securing them in forms susceptible of ready determination. Chalcopyrite was placed in a nickel crucible, containing fused potassium hydroxide. In connection with the positive pole of a battery, a heavy platinum wire from the negative pole was introduced just under the surface of the fused mass. The current was continued for ten minutes, when the contents of the crucible were dissolved out, filtered from insoluble oxides, acidified with hydrochloric acid and treated with barium chloride, when it was found that all the sulphur contained in the mineral was precipitated as barium sulphate. Comparative experiments, using the above method and also that of oxidizing with nitric acid, gave with the former method 32·35 per cent. sulphur in a specimen of chalcopyrite, and with the latter method 32·54 per cent. sulphur. The strength of the current used was one ampère.

Chromite treated in the same way as chalcopyrite yielded a little more than fifty-three per cent. Cr_2O_3 in a specimen which an older method of determination had shown to contain fifty-four per cent. Cr_2O_3.

Further experiments in this line are in progress.

The second paper, by Dr. Smith and Dr. H. F. Keller, called attention to a remarkable compound of carbon and chlorine, first produced by Dr. Smith in 1876, by the exhaustive action of chlorine on toluene exposed to sunlight, first at the boiling point and then in the cold. Analysis showed 21·41 per cent. carbon and 78·6 per cent. chlorine. The substance was crystallized from chloroform, yielding crystals measuring one-half inch in length and one-fourth inch in breadth and apparently orthorhombic.

Crystals of this compound originally melting at 152 to 153° C. were preserved for twelve years, and at the end of that time no visible alteration had taken place, but on taking the melting point this was found to have changed to 101° C., at which it remained constant after recrystallization from pure chloroform. On heating a portion of the substance in a test tube hydrochloric acid was evolved; a combustion gave 22·8 per cent. carbon and 2·2 per cent. hydrogen. Work is now going on to prepare the chloride again and to determine its vapor density as well as to study some of its derivatives. The authors wish to reserve this field of investigation for the present.

Dr. Jayne exhibited some specimens of commercial anthracenes. He stated that at present it is rarely made in the United States, as there was no market for any large quantity of the hard pitch which would be obtained in distilling tar for anthracene and as all produced would have to be sold

abroad, it was only made by a couple of firms, and then only when prices were high.

About twenty per cent. more of the tar was distilled off than when soft pitch was made, the distillate after cooling is filtered by means of a filter press. The resulting soft cake contains from ten to fifteen per cent. of anthracene, depending on the quality of the tar, the temperature of the oil and the pressure employed in filtering. This is then generally pressed in hydraulic presses, the percentage of anthracene then rising to about twenty-five to thirty per cent. This can be still further increased by treating with solvents, coal tar, naphtha, benzine, creosote oil, etc. The impurities partly dissolving and on re-pressing the residue an anthracene of about forty-five per cent. could be obtained. Recently it has been proposed to use as a solvent a mixture of solvent naphtha and the pyridine basis of coal tar; from such a solvent, it is said, anthracene of eighty per cent. can be obtained commercially. The process is said to be in operation in Germany in two factories.

The crude anthracene is not generally purified further by the tar distillers, but sold as such to the alizarine makers. The presence of any quantity of paraffines renders anthracene unsalable, as it interferes greatly with the subsequent treatments in the alizarine manufacture.

In England they are classed as A and B qualities.

A quality is an anthracene made from New Castle coal and is more valuable as it contains less paraffines.

B quality is made from Lancashire and Yorkshire coals, but it is customary to rate all anthracene not from New Castle coal as B quality, without further examination, for this reason American anthracene is considered of B quality.

It is sold at a certain price per unit or percentage of real anthracene it contains.

For instance, the present price in London is about thirty cents per unit per hundred-weight for A quality and twenty-six cents for B.

Therefore A anthracene of forty-five per cent. or units is worth 30×45 or $13.50 per hundred-weight and B quality $11.70.

The per cent. is generally determined by the amount of anthraquinone produced under certain conditions, the method being known as the "Hoechst" test. A weighed quantity dissolved in glacial acetic acid is oxidized by a solution of chromic acid in acetic acid. The resulting anthraquinone, after washing and drying, is dissolved in sulphuric acid of 1·88 on the water bath and, after complete solution, precipitated by water, and weighed, then burned and the resulting ash deducted.

Prof. R. L. Chase called attention to an article on the industrial use of oxygen in bleaching; he was requested to prepare an abstract of it for the JOURNAL.

Adjourned.

WM. C. DAY, *Secretary.*

On Diacetyl and Some of its Derivatives.*

By Harry F. Keiler.

[*A paper read before the Chemical Section at the Stated Meeting, February 19, 1889.*]

With a view to a synthetic formation of citric acid, Fittig and Daimler† subjected ethyl oxalate to the action of ethyl monochloracetate and zinc. The reaction did not take place in the desired manner, but they found among the products the ether of a dibasic, diketonic acid, which they termed ketipic (diketoadipic) acid. From the reactions of this ether it appeared highly probable that the structure of the acid must be expressed by one of the two formulæ:

$$\begin{array}{ll} CO,CH_2COOH & CO,CH_2,COOH \\ CO,CH_2COOH & CH_2,CO,COOOH \end{array}$$

It was observed that upon heating the acid was decomposed into carbonic dioxide and a yellow volatile liquid. At the suggestion of Professor Fittig I undertook the study of this reaction, in the hope of arriving at a dennite conclu sion in regard to the structure of ketipic acid. The former of the two formulæ given above proved to be correct: ketipic acid is readily split up into diacetyl and carbonic anhydride according to the equation:

$$\begin{array}{l} CO,CH_2,COOH \\ CO,CH_2,COOH \end{array} = \begin{array}{l} CO,CH_3 \\ CO,CH_3 \end{array} + 2CO_2$$

Diacetyl is the simplest orthodiketone of the fat series, a class of compounds for the production of which a great many fruitless attempts had been made. Since the discovery of its formation from ketipic acid, diacetyl has been obtained by two other reactions, viz: (1) By v. Pechmann‡ on treating isonitroso methylactone successively with acid

* From the *Inaugural Dissertation for the Degree of Doctor of Philosophy*, Strassburg, 1888.

† *Ber.*, **20**, 202.

‡ *Ber.*, **20**, 3,162.

sulphites of the alkalies and dilute sulphuric acid, and (2) by L. Wolff,* who found that it was formed by boiling β-dibrom-laevulinic acid with water.

The constitution of diacetyl is deduced from the following facts:

(1) Its empirical formulæ is $C_4H_6O_2$.

(2) It combines readily with two molecules of phenylhydrazine, of hydroxylamine and of hydrocyanic acid. It must, therefore, contain twice the carbonyl group.

(3) As the dicyanhydrin yields dimethyl racemic acid, the two carbonyl groups must be directly united.

Preparation.—In order to obtain a sufficient quantity of diacetyl for investigation, it was necessary to prepare large quantities of ketipic ether. In the beginning the method described by Daimler † was strictly adhered to, while later it was found more convenient to prepare it according to W. Wislicenus' ‡ reaction from ethyl acetate, ethyl oxalate and metallic sodium. The ether was converted into the free acid by treating it in the cold with hydrochloric acid, saturated at 0°; small quantities of it that had escaped saponification were removed by boiling the dry powdered product with chloroform, in which the acid is insoluble.

From this acid diacetyl can be obtained either by destructive distillation, or by boiling with dilute sulphuric acid.

In decomposing ketipic acid in the dry way, it was found necessary, for obtaining a satisfactory yield of the diketone, to distil *small* quantities, not exceeding five grammes at a time and to heat rapidly. The escaping vapors and gases were passed through a U-tube, provided below with a collecting bulb, and at the farther limb with an inverted condenser. The U-tube and bulb were placed in ice. The heating is continued until white fumes cease to come off. In the receiver there collects a liquid which consists of two layers; the upper one, which is of an oily appearance, is almost

* Private Communication.

† *Inaug. Diss.*, Strassburg, 1886.

‡ *Ber.*, **20**, 590.

pure diacetyl, and the lower one an aqueous solution of it. They were separated by means of a tap funnel, and sodium chloride added to the watery solution. Diacetyl and very little water passed over first on distillation. The oily layers were then united, dried with neutral chloride of calcium and fractioned. The by far greater portion distilled over between 85° to 89°, and but a small reddish-brown residue of empyreumatic odor remained in the bulb. The distillate showed a much lighter color than the original product; it was again treated with chloride of calcium, and then distilled over completely between 87°·5 and 88°.

The decomposition of ketipic acid is also readily effected by heating with dilute sulphuric acid (1:10). A violent evolution of carbonic anhydride is observed when the liquid is heated to near its boiling point, and great care must be exercised in regulating the temperature in order to avoid serious losses. The aqueous distillate is treated as described above.

The yield never exceeds fifty per cent. of the theory; it is about the same for both methods.

All attempts to obtain the monocarboxylic acid of diacetyl by splitting off only one molecule of carbonic acid were unsuccessful.

Diacetyl is a mobile liquid of an intensely yellow color and characteristic odor. It boils without decomposition between 87°·5 and 88°; the vapor is greenish yellow, resembling chlorine. Its specific gravity is 0·9734 at 22°. It is soluble in four parts of water at ordinary temperature and is miscible with alcohol and ether in all proportions.

I. 0·2563 grms. gave 0·5207 grms. CO_2 and 0·1632 grms. H_2O
II. 0·2150 " " 0·4390 " " " 0·1386 " "

	Calculated for $C_4H_6O_2$	*Found.* *I.*	*II.*
C	55·81	55·40	55·68
H	6·98	7·07	7·16

Diacetyl prepared by the reactions of v. Pechmann and of L. Wolff was found, on comparison, to be identical in every respect with that from ketipic acid.

Diacetyl shows all the reactions which are peculiar to the ketones.

It combines with the acid sulphites of the alkalies with the evolution of heat. The compound formed was not isolated, as it did not crystallize out of the solution upon standing.

When sulphurous anhydride is passed into an aqueous solution of diacetyl, its smell and color rapidly disappear; nothing can be extracted from the solution by shaking with ether. No sulphuric acid is produced by the reaction and on evaporating the liquid over sulphuric acid *in vacuo* diacetyl is regenerated. It is probable that a loose combination of the diketone with SO_2 exists, which breaks up as soon as the excess of the latter is removed.

Osazone of Diacetyl.—

$$\begin{array}{l} CH_3.C{=}N.NHC_6H_5 \\ | \\ CH_3.C{=}N.NHC_6H_5 \end{array}$$

On adding 2 mols. of phenylhydrazine to the ethereal solution of 1 mol. of diacetyl, the osazone separates out on standing in the form of beautiful yellowish needles. This compound is insoluble in most of the ordinary solvents, soluble with difficulty in $CHCl_3$, somewhat more readily in acetone, and in boiling benzol. It was obtained pure by recrystallization from the latter as a light yellowish powder, melting at 239°, with decomposition.

I. 0.3017 grms gave 0.8009 grms. CO and 0.1882 H_2O
II. 0.2213 " " 0.5870 " " " 0.1401 "
I. 0.2579 " " 46.5 cc. N at 17°.5 and 751 mm.
II. 0.2133 " " 39.2 cc. " 18° " 750 mm.

	Calculated for $C_{10}H_{12}N_2$	*Found.* I.	II.
C	72.18	72.38	72.32
H	6.76	6.93	7.03
N	21.06	21.02	21.38

Dioxim.—

$$\begin{array}{l} CH_3{-}C{=}N{-}OH \\ | \\ CH_3{-}C{=}N{-}OH \end{array}$$

This compound is formed by mixing aqueous solutions of diacetyl and of hydroxylamine hydrochloride, which has pre-

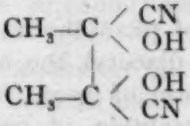
viously been neutralized with carbonate of sodium. It is precipitated white, in the form of microscopic needles. It is insoluble in water, readily soluble in alcohol and ether, and melts with partial sublimation at 234°·5. By boiling it with dilute sulphuric acid, diacetyl is again produced.

0·2380 grms. gave 0·3606 CO_2 and 0·1525 grms. H_2O
0·2278 " " 45·7 cc. N at 8° and 759 mm.

	Calculated for $C_4H_8N_2O$	*Found.*
C	41·38	41·32
H	6·90	7·11
N	24·14	24·48

A compound prepared by Schramm* in the laboratory of V. Meyer several years ago, was found to be identical with this dioxim, after a redetermination of the melting point.† It had not been analyzed.

Dicyanhydrin.—

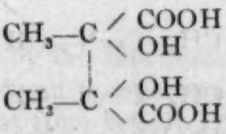


This is obtained by adding diacetyl to an excess of prussic acid in aqueous solution. The mixture is gently warmed for some time and then extracted with ether. On evaporation of the latter, the nitrile remains in the form of colorless needles or prisms, united to peculiar dendritic shapes. It is soluble in water, alcohol and ether, insoluble in all other solvents. It is very hygroscopic and decomposes when heated with water. It melts at about 110°.

0·3189 grms. dried in the desiccator gave 57·9 cc. N at 19° and 734 mm.

	Calculated for $C_6H_8N_2O_2$	*Found.*
N	20·00	20·58

Dimethylracemic Acid.—



* Schramm, *Ber.*, **16**, 179.

† Private communication of Professor Meyer to Professor Fittig.

Strecker* has observed that racemic acid is formed upon boiling glyoxal, prussic acid and dilute hydrochloric acid. It was, therefore, to be expected that diacetyl, under similar conditions, would give dimethylracemic acid.

An acid of the composition $C_6O_6H_{10}+H_2O$, and whose properties closely resemble those of racemic acid, was obtained by slightly modifying Strecker's method. It was prepared in the following manner: The finely powdered crystals of the hydrocyanide were placed in a small flask and covered with concentrated hydrochloric acid; it passed slowly into solution, but on standing, colorless crystals were observed to separate; they probably represent the acid amide. No attempt was made to determine their character, but the mixture was first heated and then the hydrochloric acid evaporated on the water bath; the residue was dissolved in water and the solution divided into two equal parts. Of these one was exactly neutralized with K_2CO_3, and boiled; the other portion was then added. Upon cooling, the acid potassium salt—which, like that of tartaric acid, is difficultly soluble—crystallized out. This was recrystallized, then converted into the neutral salt and the solution of this precipitated with acetate of lead. The lead salt was washed with water, dried, pulverized, and then suspended in water and decomposed with hydrogen sulphide. On evaporating the filtrate, the new acid crystallized out in large, shining prisms and plates. These have the habitus of crystals of racemic acid. They contain 1 mol. of H_2O, but do not effloresce in the air. The acid is readily soluble in water and in alcohol, insoluble in ether.

0·2494 grms. of air dry acid gave 0·0227 grms. loss and 0·3361 CO_2 and 0·1177 CO_2

	Required for $C_6H_{10}O_6+H_2O$	*Found.*
C	36·73	36·75
H	5·10	5·24
H_2O	9·18	9·10

The anhydrous acid melts at 180°; it is decomposed at this temperature. Heated on platinum foil, it is decom-

* *Zeitschrift f. Chem.*, 1868, 216.

posed and completely volatilized without leaving a trace of carbon.

Böttinger* has described, as dimethyltartaric acid, an acid which he obtained as a side product by the action of zinc upon an alcoholic solution of pyruvic acid. It showed no tendency to crystallize, undoubtedly because it was impure; its salts are certainly identical with some of those described below.

Potassium Salts.—The neutral salt is obtained from the acid one by exact neutralization with potassium carbonate. It is quite soluble in water, and crystallizes in needles.

The acid salt, $C_6H_9O_6K$, the preparation of which has been described above, is readily soluble in hot water, sparingly in the cold. It crystallizes in crusts or little plates. It contains no water of crystallization.

0·2526 grms. gave 0·1008 grms. K_2SO_4.

	Required for $C_6H_9O_6K$	*Found.*
K	18·05	17·92

Calcium Salts.—$C_6H_8O_6Ca + 1\frac{1}{2}$ HO.† Chloride of calcium throws down from solutions of the neutral salts of the alkalies a white crystalline precipitate, insoluble in water and acetic acid.

0·2653 grms. lost on heating to 215–220° 0·0282 grms. H_2O, and gave 0·1483 grms. $CaSO_4$.

	Calculated for $C_6H_8O_6Ca+1\frac{1}{2}H_2O$	*Found.*
H_2O	11·11	10·64
Ca	16·46	16·43

Barium Salt.—$C_6H_8O_6Ba + H_2O$. Although quite as insoluble as the calcium salt, this is not precipitated immediately by barium chloride or acetate, it separates out completely, after some time, in the form of small needles, which

---

Annalen*, **188, 315.

† Both the Ba and Ca salt were dried in the desiccator before they were analyzed; for this reason the Ba salt was found to contain less H_2O than Böttinger determined.

are generally grouped around a common centre. It contains 2 mols. of water, which are driven off at 160°.

0·2046 grms. gave 0·0211° loss and 0·1364 grams $BaSO_4$.

	Required for $C_6H_8O_6Ba + 2H_2O$	*Found.*
Ba	39·25	39·19
H_2O	10·32	10·31

The lead salt is precipitated in the form of a voluminous precipitate on adding lead acetate to the neutral potassium salt solution. It is likewise insoluble in water and in acetic acid. From acid solutions it is obtained in small needles.

In addition to the reactions described, the solution of potassium dimethylracemate gives the following: $ZnSO_4$ produces a white amorphous precipitate, insoluble in water and dilute acetic acid. $AgNO_3$ in concentrated solutions gives a white curdy precipitate. With ammoniacal silver solutions a metallic mirror is formed, especially on warming.

$HgCl_2$ throws down a white precipitate.

$CuSO_4$ is colored deep blue by the solution; the liquid remains clear on adding alkalies.

Ferric chloride produces a voluminous yellowish brown precipitate.

Halogen Derivatives of Diacetyl.—Bromine acts upon diacetyl but slowly in the cold; on warming two atoms of hydrogen are replaced. Dibromdiacetyl is best prepared by adding bromine dissolved in CS_2 or $CHCl_3$ to a similar solution of the diketone, until the red color no longer disappears on heating in the water bath. The solvent is then distilled off and the residue repeatedly crystallized from carbon disulphide and from petroleum ether. Thus obtained it forms yellow leaflets of a waxy lustre, melting at 117°. It is soluble in ether, carbon disulphide, chloroform and petroleum ether.

I. 0·2 grms. gave, after treating with Na amalgam, 0·3083 grms. AgBr.
II. 0·2 " " " boiling " Na_2CO_3 solution, 0·3079 grms. AgBr.

	Calculated for $C_6H_4Br_2O_2$	*Found.* I.	II.
Br	65·57	65·59	65·51

It is probable that the two atoms of bromine are

attached to two *different* carbon atoms, as the action of Br does not seem to proceed any further, even when a large excess is added.

Monochlordiacetyl.—By the action of chlorine upon diacetyl in the sunlight, a thick oily liquid, possessing the color of diacetyl and a pungent smell, was obtained, it did not crystallize at — 12°. Its boiling point is about 150°. Sodium carbonate solution decomposes it, especially on heating.

0·5656 grms. gave, after treating with Na_2CO_3, 0·6566 grms. AgCl.

	Required for $C_4H_5O_2Cl$	*Found.*
Cl	29·46	28·72

The further study of the halogen derivatives of diacetyl is being proceeded with.

Metallic Compounds.—When diacetyl is added to a solution of silver nitrate with *just* enough ammonia to hold the oxide of silver in solution, metallic silver is precipitated, sometimes as a mirror upon the glass; if on the other hand a large excess of ammonia be used, a voluminous white precipitate is formed, even in extremely dilute solutions of the diketone. A similar precipitate forms in ammoniacal solutions of cuprous chloride.

After drying them at 100°, these substances were analyzed with the following results:

Ag compound:

I. 0·234 grms. gave 0·2874 CO_2 and 0·892 H_2O and 0·1153 Ag.
II. 0·2368 " " 0·2898 CO_2 and 0·0923 H_2O
III. 0·294 " " 0·1442 Ag

	Required for $C_6H_9N_2Ag$	*Found.* I.	II.	III.
C	33·18	33·46	33·37	
H	4·14	4·23	4·33	
Ag	49·77	49·28		49·04

Copper compound:

I. 0·2123 grms. gave 0·3216 CO_2 and 0·1030 H_2O
II. 0·4335 " " 58·6 cc. N at 15·5° and 755 mm.
III. 0·2008 " " 0·091 CuO

	Required for $C_6H_9N_2Ag$	*Found.* I.	II.	III.
C	41·86	41·39		
H	5·23	5·35		
N	16·27		16·32	
Cu	36·62			36·14

These compounds are quite stable; at high temperatures they are decomposed with formation of acetamide.

They are evidently salts of the trimethyl glyoxaline, discovered by v. Pechmann.* This was proved also by preparing the hydrochloride of the base, by decomposing the salts with hydrochloric acid and evaporating the filtrate. The residue was recrystallized from alcohol-ether.

0·2275 grms. gave 0·2219 AgCl

	Calculated for $C_6H_{10}N_2 \cdot HCl$	*Found.*
Cl	24·38	24·13

The free base was liberated with sodium carbonate and extracted with ether. Recrystallized from a mixture of ether and ligroin, it forms small white needles which have a bitter taste and melt at 130 or 131°.

ON THE COMPOUND $C_{21}Cl_{26}$.

By EDGAR F. SMITH and HARRY F. KELLER.

[*Read at the Stated Meeting of the Chemical Section, March 19, 1889.*]

In 1876,† one of us (S.) described a compound, containing only carbon and chlorine. It was obtained by the exhaustive chlorination of toluene exposed to sunlight, first at the boiling temperature and then in the cold. Several analyses of the purified product showed the presence of 21·40 per cent. carbon and 78·6 per cent. chlorine. The only solvent employed at the time was chloroform, and from such a solution crystals, measuring one-half inch in length and one-fourth inch in breadth, were obtained. The forms were apparently orthorhombic. The melting point, taken after each of a series of re-crystallizations, remained constant at 152°–153° C. To this rather interesting derivative the improbable formula $C_{21}Cl_{26}$ was ascribed. Nascent

* *Ber.* **21,** 1411.

† *Dissertation.* Goettingen, 1876; *Jahresbericht,* 1877, p. 421; *Am. Phil. Soc.,* **17,** p. 29.

hydrogen acted with difficulty upon it. After an exposure of two months to the influence of zinc and sulphuric acid, it was scarcely changed, inasmuch as an analysis of the product gave 21·69 per cent. carbon, 77·76 per cent chlorine and one per cent. hydrogen.

Nothing further was done with the compound until about five years later, when a portion of it was treated in a sealed tube with an excess of aniline (*Am. Chem. Jour.*, vol. 1, p. 150). By this treatment a base was formed, melting at 230° C. Its hydrochloric acid salt was analyzed.

Crystals of the original compound, in its purest condition, were preserved for twelve years without undergoing any visible alteration, and it was but natural that we should be surprised, on fusing some of this same material, to find it melting at 101° C. This melting point remained constant, even after re-crystallization from pure chloroform. On heating a portion of the substance in a test tube, we observed that hydrochloric acid gas was evolved. A combustion gave 22·8 per cent. carbon and 2·2 per cent. hydrogen. A vapor density determination was carried out, but as we had evidence of decomposition, we place no reliance on the result. Every possible precaution was observed in the combustion, in order that we might arrive at the true hydrogen percentage, and that given above would indicate but slight change from the original constitution. Work is now being prosecuted, with a view of obtaining the carbon chloride, when it is proposed to pay especial attention to the solution of its molecular formula and to the study of some of its derivatives. We, therefore, request those who may have entertained the idea of investigating this compound to postpone their work, and leave the field to us at least for a few months.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, March 15, 1889.

OXIDATIONS BY MEANS OF THE ELECTRIC CURRENT.

By EDGAR F. SMITH.

[*Read at the Stated Meeting of the Chemical Section, March 19, 1889.*]

In using the electric current for the determination and separation of metals, it occurred to me that its oxidizing power might be utilized to convert sulphur and other elements into higher oxides, thus bringing them into forms in which they could be readily determined. To test this I undertook the oxidation of the sulphur in chalcopyrite after the following manner: About ten grammes of solid potassium hydroxide were placed in a small nickel crucible, and carefully heated over a Bunsen burner until the water was expelled, when the flame was reduced, so that its heat was just sufficient to retain the alkali in liquid form. The crucible was put in connection with the positive pole of a battery, and the powdered mineral placed upon the alkali. A heavy platinum wire, from the negative pole, extended just under the surface of the fused mass, and when the current was passed, a lively action ensued, accompanied with considerable spattering. Loss was prevented by placing a perforated watch crystal over the crucible. When the action had continued for ten minutes the connection was broken, the crucible and its contents allowed to cool, placed in a beaker, covered with water and warmed upon an iron plate. On filtering off the insoluble oxides, the filtrate was blue in color, due to a little copper. The liquid was acidulated with hydrochloric acid, and care taken to detect any hydrogen sulphide or sulphur dioxide, which are always present, when the oxidation of the sulphur is incomplete. In this particular case all the sulphur was changed to sulphuric acid, and removed as barium sulphate. When ignited the latter presented a perfectly white appearance, showing not the slightest trace of iron.

Having succeeded so well with the first portion I weighed

off ·1734 gramme chalcopyrite, subjected it to a like treatment, and obtained ·4086 gramme $BaSO_4$ = ·0561 gramme S or 32·35 per cent. S. One of my students oxidized another portion (·5 gramme) of the same material with nitric acid and potassium chlorate, and obtained 32·54 per cent. sulphur.

The current used above registered one ampère (10·45 cc. H-O gas) per minute as it passed through the fused alkali. The solution containing the potassium sulphate contained no iron. A little copper was present in it. The residue of oxides (Fe_2O_3, CuO, etc.) should dissolve readily and completely in warm hydrochloric acid. There may, however be a residual mass, red in color, but this can be disregarded, as it is only metallic copper. In some of the oxidations the wire attached to the negative pole was coated red by copper, or with a black deposit of metallic iron. The idea suggested itself to me that, as the metal was depositing as such, it might possibly inclose some mineral, as yet unacted upon, and thus withdraw it from the field of oxidation. I therefore invariably, in every determination, reversed the current for a few minutes before its final interruption. This seems to have been unnecessary with chalcopyrite, but was required with some other minerals with which similar experiments were tried.

With a chalcopyrite, different from that analyzed before, the following percentages of sulphur were obtained :—

(1) 29·9 per cent S—(2) 30·11 per cent S—(3) 29·7 per cent S.

The quantity of mineral used was in (1) ·1528 gramme, in (2) ·1445 gramme and in (3) ·1082 gramme. About 10 grammes of potassium hydroxide were used in each determination. The current was one ampère, acting for a period of ten minutes. In working with a quantity of mineral varying from ·2 — ·3 gramme, the quantity of alkali should be doubled.

This method affords a rapid oxidation of sulphur to sulphuric acid, so that the inconveniences arising from the slow, time-consuming method with nitric acid and potassium chlorate, or that with nitric acid alone, can be avoided, where a current of the strength indicated above can be obtained.

Iron salts also are removed. I have endeavored to oxidize the sulphur of pyrite by this means, but thus far the experiments have been fruitless. I have not obtained more than half of the sulphur in the form of sulphate. Even when the current acted for thirty minutes, the result was no better. The cause of this singular behavior appears to be due to the presence of the iron. I expect, however, to so modify the experiment in this case that pyrite may yet be as easily oxidized as chalcopyrite.

As time permits, this mode of oxidation will be extended to other natural sulphides and to compounds containing sulphur.

My experiments in oxidizing with the current really began with chromite. It was treated the same as the chalcopyrite. Twice I obtained a little over fifty-three per cent. Cr_2O_3 from a specimen of this mineral, which by an older method gave fifty-four per cent. Cr_2O_3. At present I am not prepared to say anything more in regard to this mineral. Some difficulties have appeared which require solution before entering into details.

Nickel crucibles as well as iron have been used in this work, and with chromite an old platinum vessel was made to do service. The crucibles were one and one-fourth inches in height, and one and three-eighths inches wide; the most convenient form would be that measuring two inches in length, and one and one-half inches in width.

In closing I must extend my sincere thanks to Mr. D. L. Wallace, of this laboratory, for his kind assistance, without which it would have been impossible for me to carry out these experiments at this time.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, March 19, 1889.

DISCUSSION.

Mr. PEMBERTON.—The application of the electric current as an oxidizing agent in chemical analysis is certainly most interesting. So far as the particular application to the analysis of pyrite is concerned, the process would be open

to the objection brought forward by Dr. Lunge to other methods of analyzing by alkaline fusion. Sulphur, present in combination (as in galenite or barite), would be reckoned available for sulphuric acid manufacture. This, however, relates to only one use of the process and is of minor importance. The principle involved is of wide application, and is a new and interesting departure in chemical analysis.

THE TESTING OF LOGWOOD EXTRACTS.

BY T. CHALKLEY PALMER.

[*Read at the Stated Meeting of the Chemical Section*, FRANKLIN INSTITUTE, *March 19, 1889.*]

The continued paper of Dr. Bruehl, now appearing in the *Textile Colorist*, on "Dyewood Extracts, etc.," while of great importance and generally very practical, contains some statements that may be challenged. This is noticeably the case when the author discusses Trimble's method of estimating the tinctorial value of logwood extracts. The description of this method, given on page 5 of the January issue, is in outline correct, but some particulars of an essential nature are not given, and the capabilities of the process are certainly misapprehended.

In order to operate successfully with this test, the following conditions must be observed. The bluestone or copper-sulphate solution, as well as the solution of extract, must be made with distilled water. The water used for dilution in the graduated cylinders, if pure distilled water, will give a reddish-purple color, quickly fading, and useless for a standard of comparison, even during ten minutes. If river or hydrant water is used, the precipitate forms into flocks immediately, and settles to the bottom of the cylinder, being likewise useless. It has been found, in practice, that the water for dilution should be three-fourths distilled water and one-fourth hydrant water. The explanation of this necessity for a certain amount of ordinary water is not, so far, at all clear; but probably a trace of ammonia, or still

more a trace of lime, is necessary to the production of the blue, finely divided lake of logwood and copper oxide. The quantity of the blue compound is, however, so minute that the slightest excess of this agent, be it what it may, produces results akin to over-oxidation.

It would, of course, be more scientific to take pure distilled water, and add enough of the needed reagent, whatever it may be, to produce the result; but the nature of this reagent not being known, and a mixture of water, as given above, producing good results, I have contented myself with this process. It only needs to be further pointed out, that as natural waters vary, varying proportions may have to be used in different places. The above proportions are for Schuylkill water.

In comparing two cylinders by this process, instead of looking at the two from above, as stated by Dr. Bruehl, it is necessary to look at them from the side; in fact, in a direction at right angles to the length of the cylinders. It is a good plan to cut off the view of the meniscus with a piece of paper or with the hand, thus leaving visible for comparison two bands of color, not complicated with any inequalities. If one looks into the tops of the cylinders, and if he has in one a standard diluted to 100 cc., and beside it an adulterated extract diluted to 50 cc., he is then comparing two columns of color, of equal richness, to be sure, but of which one is twice as deep as the other. It is very evident that this would lead to a serious error. If, on the other hand, he compares these two cylinders by a side view, he is looking through two columns of equal thickness. By this method of procedure he can get results accurate within two per cent. The description of the method has been already given pretty fully elsewhere, and though it may appear complex, is really very expeditious.

Now, in regard to the conclusion of Dr. Bruehl, that tannin-bearing matters have a disturbing effect on this reaction and that wrong values will consequently be obtained for extracts adulterated with hemlock, chestnut, etc., it is to be said that this is altogether erroneous. After a rather extensive experience in using this method, I have

perceived very clearly that it constitutes a laboratory assay rather than a dye-house test; that is, it shows more concerning the purity and the mode of manufacture of an extract of logwood than it does of its practical and effective value in the dye-house. Let me make this clear, and in doing so, it will be perceived that what the method lacks in one respect it gains in another.

Everybody knows that hemlock, chestnut, and still more cutch and sumac, are not absolute and unqualified adulterants when considered from the dyer's point of view. Most warp and other cotton-dyers habitually add cutch and hemlock to their dye-baths, either knowingly and avowedly or unknowingly under various fancy names. The *rôle* of these materials is two fold; they act as real coloring matters, producing colored lakes with the metallic salts used in dyeing, and they serve as "fasteners" or accessory mordants, aiding the ultimate color to withstand washing operations that follow dyeing. This is very ancient history. Consequently, it is far from surprising that any one who has not used Trimble's method should suppose that an equivalent result would be obtained here; that the tannins present in the extracts in question would help to form colored lakes; but it is difficult for the writer of these lines to understand how anyone can think so who has done more than meditate on the subject.

The facts in the case are these. If you weigh out three equal quantities of a given extract of logwood, and if you add to one of these an equal weight of glucose, and to another an equal weight of hemlock extract, and test the three against each other, you will get, using the pure extract for standard at 100 cc., for the one mixed with glucose, 50 cc., and for the one mixed with hemlock, almost exactly the same, but possibly 51 cc. or 52 cc. It is evident from this, that any lake produced by the union of the hemlock tannin and the copper oxide is, under the peculiar conditions of this test, colorless or nearly so. Why this should be so here, and not so under the conditions that obtain in the dye-house, it is not easy to explain, but there is no room for dispute concerning the facts.

The following results will bear out this statement of the case, being selected from many others obtained by this method on account of their bearing on the point at issue.

	Description of Extract.	Observed Dilution.	Theoretical Dilution.
		cc.	cc.
1	Extract logwood, 100 per cent. (Standard), ...	100·0	. . .
2	" " 85 " : Extract hemlock, 15 per cent.,	86·0	85·0
3	" " 80 " : " " 20 "	79·0	80·0
4	" " 75 " : Glucose, 25 "	75·0	75·0
5	" " 70 " : " 30 "	69·5	70·0
6	" " 66·6 " : Extract chestnut, 33·3 "	65·5	66·6
7	" " 65 " : Cutch, 25 per cent.; glucose, 10 per cent., ...	64·0	65·0
8	" " 50 " : Molasses, 50 per cent., ...	48·0	50·0
9	" " 33·3 " : " 66·6 "	33·0	33·3

It is evident that we have in this method the nearest approach to a scientific assay of logwood so far devised. By means of it we arrive at the absolute amount (roundly speaking) of logwood extract in any given sample, let the adulterant be any one or two of the substances mentioned in the above table. No doubt many things might be added to an extract of logwood that would interfere with this test, but none of the ordinary adulterants appear to do so.

Finally, the method appears capable of extension in certain directions, whereby its scientific value may be increased very greatly. If this extension proves practicable, further communication will be made concerning it.

ABSTRACTS.

On the Volumetric Determination of Sulphur by Means of Baric Chloride. C. and J. J. Beringer (*Chemical News*, **59**, 41) find this method satisfactory, if acetic acid (10 cc.) and sodium acetate (10 grammes) be added to the solution of the sulphate. The presence of free mineral acids, or of nitrates and chlorides is not objectionable, provided enough sodium acetate be added to convert all into sodium salts. L. B. H.

Commercial Production of Oxygen.—At the Stated Meeting of the Chemical Section, held March 19th, Prof. R. L. Chase made the following remarks on the commercial production of oxygen: In the *Journal of the Society of Chemical Industry*, of February 28th, there is an interesting article on "Some Industrial Applications of Oxygen." It is claimed that the gas can be manufactured in London at a cost of not over 7*s*. 6*d*. per 1,000 cubic feet.

In bleaching with chloride of lime, it was found that the addition of oxygen not only accelerated the bleaching process, but also reduced the amount of bleach necessary. Some laboratory experiments with paper pulp showed a saving of from forty to fifty per cent. in the amount of bleach necessary. A practical experiment in the large way, and carried out under somewhat disadvantageous conditions, showed a saving of thirty per cent. in bleach.

The bleaching power of free chlorine was also very largely increased by the addition of oxygen.

In the purification of illuminating gas from sulphur compounds, it was found that by the addition of oxygen the lime purifiers alone were sufficient to remove all sulphur compounds, and that the lime could be used nearly twice as long as usual. Also that the luminosity of the gas was slightly increased instead of there being a decrease, as is the case when air is used.

For the maturing of spirits, it was found that by the addition of oxygen at a pressure of one or more atmospheres for ten days, the spirits were mellowed to an amount equal to that produced by three to five years' ageing. The amount of fusel oil was also largely reduced.

RESEARCHES ON SILICIUM AND BORON.—Ludwig Gattermann, *Berichte*, **22**, 186.—The author prepares silicium by heating together powdered magnesium and powdered quartz.

$$SiO_2 + 2\,Mg = Si + 2\,MgO$$

The various silicium preparations can be made from the grayish-black reaction product. If it be desired to prepare crystallized silicium, the crude silicium is heated in a luted crucible with zinc, care being taken that the temperature remains below the boiling point of the latter. By treating the fused mass with hydrochloric acid the zinc is dissolved, and steel-blue needles of silicium are obtained.

Boron may be similarly obtained by heating borax with powdered magnesium. After washing with water and then with hydrochloric acid, the residual brownish-gray powder consists mostly of boron, which may be obtained beautifully crystallized by fusion with aluminium. S. C. H.

BOOK NOTICES.

THE ANIMAL LIFE OF OUR SEA-SHORE; WITH ESPECIAL REFERENCE TO THE NEW JERSEY COAST AND THE SOUTHERN SHORE OF LONG ISLAND. By Angelo Heilprin, Professor of Invertebrate Paleontology and Curator in Charge Academy of Natural Sciences of Philadelphia, etc. Philadelphia: J. B. Lippincott Co., 1888,

Professor Heilprin, in this little book, has added another to his series of handy volumes for the use of that sojourner on our sea-coast, who has an idea above the Monmouth races, the occasional "hops," and the distractions of billiards and poker. Even to those who are ardent deep sea fishermen, the

book proves most interesting, although the subject is rather the jetsam of the ocean on its shore. The description of the strange and often mutilated remains, which one finds on the beach, is given in clear and simple language, and the numerous illustrations are generally satisfactory and well chosen. If a criticism might be ventured here, it would be that printer's ink has been unequally and often too largely used in printing the cuts. This apart, the little book ought to have a large sale, as it is in good form for the pocket, well conceived and interesting. F.

ELEMENTS OF MACHINE DESIGN, NOTES AND PLATES, FOR THE USE OF STUDENTS IN LEHIGH UNIVERSITY. By J. F. Klein, Professor of Mechanical Engineering. The Comenius Press, Bethlehem, Pa.

Fortunately the preface of this book states that it is not a complete treatise, even on the machine parts represented, frequent reference to the larger works of Reuleaux and Unwin being desirable.

There are fourteen plates, which form the sub-divisions of the text.

Plate I treats of different kinds of screw threads, giving formulæ for proper diameter for given working load when used for fastenings, for steam tight joints and for transmitting motion, together with proportions for the various standard threads in use.

Plate II gives different kinds of bolts, with methods of locking the nuts in place. The proportions are good, except as to chamfering. The round heads of the screws are too small in proportion to the bodies. This plate is not up to modern standards and omits many important points.

Plate III treats of rivets and riveted joints and gives standard formulæ.

Plate IV gives examples of and formulæ for joints for connecting plates not in the same plane.

These two plates on boiler work are such a mere skeleton of the subject that in many cases a student would have to refer to Rankine or Reuleaux to obtain a clear understanding.

Plate V treats of keys and methods of fastening hubs to shafts and shafts in sockets, and also straps to ends of connecting-rods. The formulæ are entirely unexplained, and the rationale of the subject not touched upon.

Plate VI treats of methods of drawing the curves of gear teeth, and is very unsatisfactory. It is based on the theory of axoids and centroids, as explained by Reuleaux, but to anyone not thoroughly acquainted with Reuleaux's work these chapters would be of little use. The different shapes of teeth, their advantages and disadvantages and methods of describing the exact and approximate curves are only partially explained. This matter covers thirteen pages of texts, while twenty pages of the same chapter are devoted to a method of "Profiling of Teeth by Rectangular Co-ordinates," which has been devised by the author. The first sentence states that "this method is at once the simplest and most exact, involving only capacity to use the square and to lay off distances accurately." Some conception of the extent of the capacity which is "only" thus involved may be obtained by examining the first figure, which is given on page 51. This is the profile of the tooth of

a rack, the diametral pitch of which is two, or about one and one-half inches, actual pitch. In the first place, this is a relatively large pitch, the great majority of gears to be cut or for which patterns are to be made in ordinary practice having much smaller pitches than this. But, taking this rack tooth of one and one-half inches pitch, the requirements of this "simplest and most exact" system are that eight lines shall be drawn parallel to and on each side of the pitch line at a distance apart of 0·075 inches, and that the following distances from the radial reference line be laid off on these lines consecutively: ·008″, ·023″, ·042″, ·065″, ·092″, ·122″, ·155″ and ·191″.

The claim that this method is simple and exact, in view of the extreme difficulty of laying off the above dimensions for this relatively large pitch, is preposterous, even when the figures are already selected; but when, in addition to this, great judgment and care have to be exercised in selecting the proper figures from the proper table, the liability to error becomes so great that one would never feel confident of the result without verifying it by one of the simple and exact methods in general use.

Plate VII continues the subject of spur gearing, quoting Reuleaux, Rankine and Willis, and giving formulæ for proportions and strength. It is to be regretted that the author did not devote the ability and perseverance displayed by his tables of co-ordinates, to the making of tables of ultimate strength for gear teeth. Such tables are greatly needed to enable engineers and designers to avoid the constantly recurring calculations to determine the pitch and length of face of tooth required to stand a given stress at the pitch line.

This chapter also gives proportions for shafts, arms and wooden teeth and treats of equidistant values of cutters, but maintains the general air of obscurity and mystery which pervades the book.

Plate VIII, "Problems in Gearing" is good. It contains information and is capable of imparting instruction to any student who has been sufficiently prepared to receive it, although such preparation could not be obtained from this book.

Plate IX, on "Bevel Gearing," is also very good, although to anyone not already well up on the subject, it would prove rather difficult to understand.

The author adheres to the old idea of the necessity of a "Hunting Tooth," and would sacrifice the accuracy and simplicity of the velocity ratio to gain such a tooth.

Plate X on "Worm Gearing," begins with an obscure reference to hyperboloidal wheels and screw gearing which had better have been omitted. Even the part on "Worm Gearing" is more notable for what it omits than for what it gives.

Plate XI on "Belt Gearing" follows closely Reuleaux' presentation of the subject, and gives much useful information very concisely.

Plate XII, gives an original, complete and scholarly treatment of the subject of cone pulleys, with formulæ and extensive tables for determining the diameters required to secure equal tension of the belt on all the steps of the cones. This, however, is a refinement which is rarely called for, because the distance between centres of the pulleys should, if possible, be kept great

enough to secure efficient and satisfactory working of the belt, and, if this is done, the change of length of the belt, due to its angularity, will be inconsiderable.

Plate XIII, on rotating pieces, is good.

Plate XIV, on bearings, is misleading in its condemnation of cast-iron bearings and its advocacy of universal babbitting, and does not by any means cover the ground it should. The part on connecting rods, however, is good.

Taking the book as a whole, it is difficult to see the benefit of it to anyone, excepting local students who have been trained in a certain manner and up to a certain point.

It may be valuable as "Notes for the use of Students in Lehigh University," but is not so as a treatise on the "Elements of Machine Design."

W. H. T.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Agricultural Experiment Station, Auburn, Ala. Bulletin No. 3, new Series. From the Station.

Alabama Railroad Commissioners. Eighth Annual Report for year ending June 30, 1888. From the Commissioners.

American Public Health Association. Report of the Committee on the Pollution of Water Supplies. From the State Board of Health of Michigan.

American Institute of Mining Engineers. Eight pamphlets, subject to revision. From the Institute.

Atlanta. Fourteenth Annual Report of the Board of Water Commissioners for the year 1888. From the Board.

Boston Water Board. Report of the Water Meter Testing Commission. From the Board.

California State Mining Bureau. Eighth Annual Report of the State Mineralogist. From the Bureau.

Cincinnati Public Library. Bulletin of books added during 1888. From the Library.

Cincinnati Water Department. Forty-seventh and Forty-eighth Annual Reports for 1886 and 1887. From the Department.

Columbus Water Works. Annual Report. 1882–83. From the Works.

Dakota School of Mines. Preliminary Report upon the Geology, Mineral Resources and Mills of the Black Hills of Dakota. From Franklin R. Carpenter, Dean.

Dayton, O. Annual Reports of the Water Works Trustees. 8th, 16th, 17th and 18th for 1877, 1885, 1886 and 1887. From the Water Works.

Department of Agriculture, U. S. Botanical Division. Bulletin No. 8.

Division of Entomology. Periodical Bulletin, No. 8.

Department of Agriculture, U. S. Report of the Statistician. No. 59. From the Department.

Engineer Department, U. S. A. Annual report upon the improvement and care of the public buildings and grounds in the District of Columbia and Washington aqueduct. 1875 and 1878.

Annual reports upon the Washington aqueduct, increasing water supply of Washington and erection of fish-ways at the Great Falls of the Potomac. 1885 to 1888.

From Major G. J. Lydecker, in charge.

Engineer Department, U. S. Annual reports of O. E. Babcock, John M. Wilson (and others) upon the improvement and care of the public buildings and grounds in the District of Columbia. 1872, 1874, 1876, 1880 to 1888.

From Col. John M. Wilson.

Engineers' Society of Western Pennsylvania. Ninth Annual Meeting and Three Papers. From the Society.

Erie, Pa. Annual Report of the Board of Water Commissioners for 1886 and 1887. From the Board.

Fall River, Mass. Fifteenth Annual Report of the Watuppa Water Board to the City Council. January 1, 1889. From the Board.

Fletcher, Alice C. Indian Education and Civilization. Senate Executive Document. 1885. From the Department of State.

Franklin Machine Works. Catalogue of Machinery. From H. P. Feister.

Frazer, Persifor. Archæan Characters of the Rocks of the Nucleal Ranges of the Antilles. From the Author.

Friends' Free Library, Germantown. Report for 1888. From the Library.

General Land Office, U. S. Annual Report of the Commissioner. 1885 to 1888, inclusive. From the Office.

General Society of Mechanics and Tradesmen of the City of New York. Annual Report. From the Secretary of the Society.

Geological and Topographical Map of the New Boston and Morea Coal Lands in Schuylkill County, Pa. From Benj. S. Lyman.

Germanischer Lloyd. Internationales Register. 1888 and 1889. From L. Westergaard & Co.

Harris-Corliss Engine. Catalogue. From the W. A. Harris Steam Engine Company.

Hartford, Conn. Report of W. E. Worthen, upon an additional supply of water. March, 1864.

Report relative to new reservoir. 1878.

Reports on supply of water from Farmington River. 1878. From the Hartford Water Works.

Hartford Steam Boiler Inspection and Insurance Company. Some Recent Boiler Explosions. From the Company.

Hydrographic Office, U. S. Nautical Monograph No. 5. The Great Storm off the Atlantic Coast of the United States. March 11–14, 1888.
From Lieut. G. L. Dyer.

Idaho. Reports of the Governor to the Secretary of the Interior. 1885 to 1888.
From the Governor.

Iowa State Board of Health. First to Fourth Biennial Reports. 1881 to 1887. Monthly Bulletins. Vol. 1. Nos. 3, 5, 7, 9, 11, 12. Vol. 2. Nos. 1 to 7. 1888. From the Board.

Ives, F. E. A New Principle in Heliochromy. From the Author.

Kansas State Board of Agriculture. Advance Sheets Sixth Biennial Report.
From the Board.

Landis, C. K. Map of the Proposed Grand Avenue to the Park.
From C. K. Landis.

Leominster, Mass. Sixth, Seventh, Eighth, Twelfth to Sixteenth Annual Reports of the Water Board for years ending March 1878 to 1880, and 1884 to 1888. From the Board.

Levytype Company of Philadelphia. Specimen Sheets.
From the Company.

Locomotives. Six charts illustrating types of European and American locomotives, between the years 1771 and 1882.
From Wm. Kite, Librarian Friends' Library.

Lynn. Seventeenth Annual Report of the Public Water Board for 1888.
From the Board.

Madison, Wisconsin. Sixth Annual Report of the Board of Water Commissioners, for year ending October 1, 1888. From the Board.

Making of a Paper. Patents. From the W. J. Johnston Company.

Manchester (England) Free Public Libraries. Hand-book, historical and descriptive. From the Librarian.

Manchester (England) Statistical Society. The free library movement in Manchester. By W. R. Credland.
From the Librarian, Manchester Free Public Libraries.

Massachusetts Agricultural College. Twenty-sixth Annual Report.
From the College.

Massachusetts. Board of Commissioners of Savings Banks. Annual Report for 1888.

Massachusetts State Library. Report of the Librarian for 1888.
From the Library.

Mechanics' Institute of San Francisco. Report of the Twenty-third Exhibition. From the Institute.

Meriden Scientific Association. Transactions. Vol. 3.
From the Association.

Meteorological Council. Royal Society. Hourly Readings. 1886. Part 1.
Weekly Weather Report. October 1st to December 31, 1888.
Report to the Royal Society for the year ending March, 1888. From the Council.

Montana. Reports of the Governor to the Secretary of the Interior for the years 1878, 1881, 1883, 1885, 1887 and 1888.
Third Annual Report of the Superintendent of Public Instruction for the year 1881. From the Governor of Montana.

National Electric Light Association. Bulletin No. 6. Sixth Series.
From the W. J. Johnston Company.

New Jersey. Adjutant-General's Reports for 1861 to 1886, excepting for 1862, 1866, 1870, 1874 and 1880. From the Adjutant-General.

Newark, N. J. A History of the Old Burying Grounds as contained in the case of the Attorney-General against the City of Newark. 1888.
From the Society.

New York State Agricultural Society. Transactions. Vol. 34. 1883–1886.
From the Society.

North Carolina Agricultural Experiment Station. Bulletin No. 62.
From the Station.

Ohio State Board of Agriculture. Annual Reports. 37th, 38th and 42d for 1882, 1883 and 1887. From the Board.

Ohio State Tramway Association. Proceedings. 1888.
From the Association.

Ohio Valley Centennial Exhibition. Exhibit of the Navy Department.
From Lieut. Richard Rush, Navy Representative.

Oldham, R. D. A Bibliography of Indian Geology.
From the Director, Geological Survey of India.

Ordnance Department, U. S. A. Annual Report of the Chief.
From the Chief.

Parrish, Joseph. Climate and Malaria. Medical Jurisprudence of Inebriety.
From the Author.

Patent Office, U. S. Specifications and Drawings. February, 1888.
From the Office.

Pennsylvania Canal Company. Eighth to Twenty-second Annual Reports.
From Mr. Horace Whiteman, Secretary.

Pennsylvania Railroad Company. Forty-second Annual Report.
From the Company.

Philadelphia and Erie Railroad Company. Thirty-eighth Annual Report.
From the Company.

Philadelphia and Reading Railroad Company. Report for 1888.
From the Company.

Philadelphia Social Science Association. Industrial Education in Europe. By L. W. Miller. From the Association.

Popular Science Monthly. July to November, 1885.
From Spencer Fullerton.

Rogers, Henry R. Absolute Vacuum.
Ice-lens of 1608. From the Author.

St. Louis Public Library. Annual Report 1887–88. From the Librarian.

San Francisco Municipal Reports, 1880–81, 1883–84, 1885–86, 1886–87, 1887–88. From the Board of Supervisors.

Shinn, J. Improvement in the Manufacture of Heavy Guns and Shafts. From the Author.

Signal Office, U. S. Daily International Chart. December, 1887. Summary and Review of International Meteorological Observations. December, 1887. From the Office.

Stead, J. C. Useful Information Relative to the Economical Generation and Employment of Steam. From F. Leclere.

Storr's School Agricultural Experiment Station. Bulletin No. 3. From the Station.

Summit Branch Railroad Company and Lykens Valley Coal Company. Annual Report for 1887 and 1888. From the Companies.

Syracuse, N. Y. Report of Commissioners on Sources of Water Supply. From J. J. R. Croes, New York City.

Syracuse, N. Y. Report of Commissioners on Sources of Water Supply. From the City Clerk.

Taunton, Mass. First and Third Annual Reports of the Water Commissioners for 1876 and 1878. (2 copies each.) From the Commissioners.

Texas. Geological and Mineralogical Survey. First report of progress. E. T. Dumble, State Geologist. 1888. From the State Geologist.

Treasury Department, U. S. Comptroller of Currency. Annual Report. 1888. Vol. 2.
Annual Report of the Secretary for 1888. From the Department.

Virginia. Annual Report of the Commissioner of Fisheries. 1882. From the Commissioner.

Wisconsin Farmers' Institutes. 1888. Bulletin No. 2. From W. H. Morrisson, Superintendent.

Wisconsin State Board of Supervision. First to Third Biennial Reports. 1883–84 to 1887–88. From the Board.

Wyoming Territory. Reports of the Governor to the Secretary of the Interior. 1886, 1887 and 1888. From the Governor.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, March 20, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 20, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, 170 members and seventy visitors.

Additions to membership during the past month, sixty-seven.

The special committee to increase membership made a report of progress and was continued.

The special committee to prepare a memorial of the late WILLIAM PETTIT,

member of the INSTITUTE, presented a report, which was accepted and referred to the Committee on Publications.

Mr. WM. B. LE VAN presented a communication on the compound locomotive, giving historical account of the development of this improved form of engine, with especial reference to the English-built locomotive, "Dreadnaught," lately purchased by the Pennsylvania Railroad Company. Mr. LE VAN's remarks were illustrated with the aid of the lantern. (Referred for publication.)

Capt. E. L. ZALINSKI, U.S.A., read a paper on the "Pneumatic Dynamite Gun," giving a history of the experiments that had been made and the results attained in the art of throwing projectiles charged with high explosives from guns, with the aid of compressed air. The paper was fully illustrated with the aid of lantern pictures and the exhibition of important parts of the electrical discharging appliances employed. The paper evoked considerable discussion and has been referred for publication.

The thanks of the meeting were unanimously tendered to Captain ZALINSKI at the close of his address.

The President named the following standing committees of the INSTITUTE for the current year, viz:

STANDING COMMITTEES OF THE FRANKLIN INSTITUTE FOR THE YEAR 1889.

Library.	*Minerals.*	*Models.*
Charles Bullock,	Clarence S. Bement,	Edward Brown,
J. Howard Gibson,	Persifor Frazer,	John H. Cooper,
Fred'k Gratf,	F. A. Genth,	C. Chabot,
Geo. A. Koenig,	Edwin J. Houston,	L. L. Cheney,
S. H. Needles,	George A. Koenig,	N. H. Edgerton,
Isaac Norris, Jr.,	Otto Lüthy,	John Goehring,
Chas. E. Ronaldson,	E. F. Moody,	Morris L. Orum,
Wm. P. Tatham,	H. Pemberton, Jr.,	Chas. Richardson,
John C. Trautwine, Jr.,	Theo. D. Rand,	John J. Weaver,
Lewis S. Ware.	Wm. H. Wahl.	S. Lloyd Wiegand.

Arts and Manufactures.	*Meteorology.*	*Meetings.*
J. Sellers Bancroft,	Lorin Blodget,	Hugo Bilgram,
George Burnham,	Charles M. Cresson,	Geo. V. Cresson,
Cyrus Chambers, Jr.,	Edwin J. Houston,	G. M. Eldridge,
Franklin M. Harris,	Isaac Norris, Jr.,	Fred'k Graff,
Wm. B. Le Van,	Alex. E. Outerbridge, Jr.,	Henry R. Heyl,
C. C. Newton,	J. S. W. Phillips,	Washington Jones,
Henry Pemberton,	M. B. Snyder,	G. H. Perkins,
Alex. Scott,	Wm. P. Tatham,	Sam'l R. Marshall,
Thomas Shaw,	H. Wiley Thomas,	Chas. E. Ronaldson,
Wm. Vollmer.	Wm. H. Wahl.	Wm. H. Thorne.

Adjourned.

WM. H. WAHL, *Secretary.*

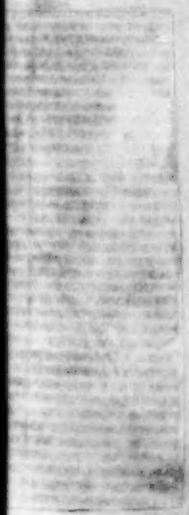


FIG. 5.—Rail which broke in service, causing a wreck. Shows result of longitudinal defects in the ingot from which it was rolled.

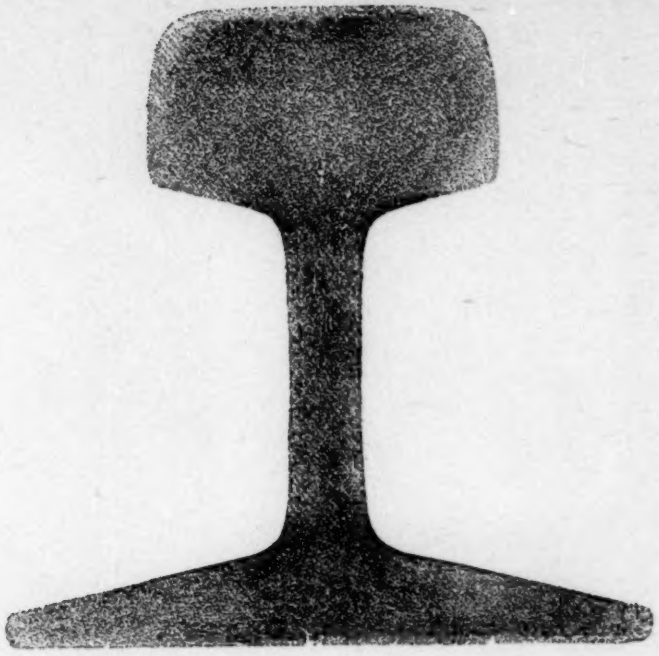


FIG. 8.—Etching of a nearly sound rail.

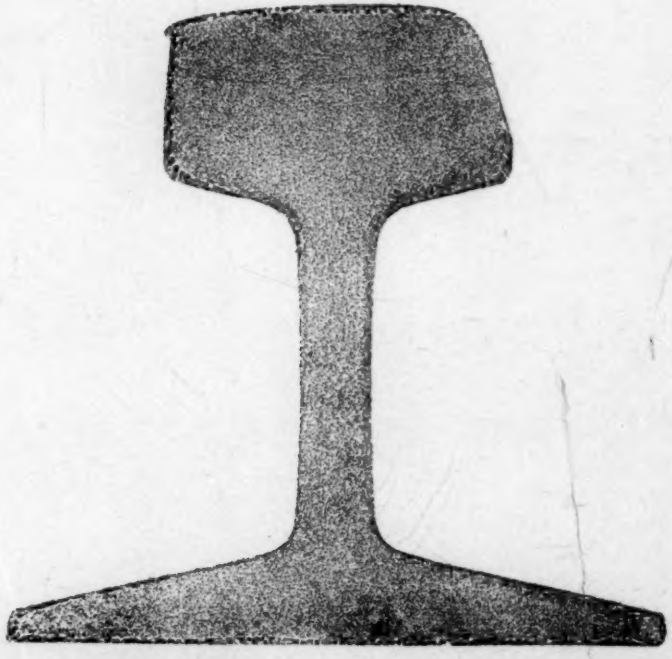


FIG. 9.—Etching taken from a rail which had rendered good service, and which presents a sound and fine-grained metal.

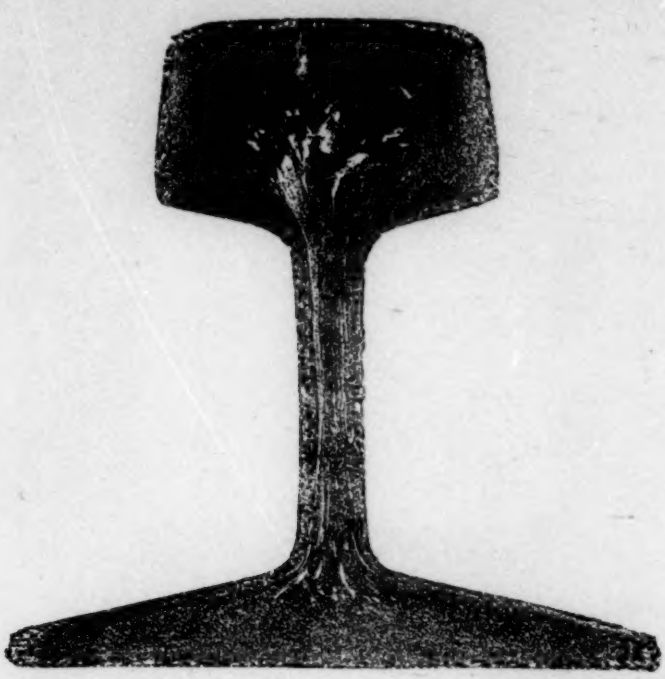


FIG. 6.—Etching showing same character of unsoundness as *Fig. 5*, but i
less degree.

FIG. 7.—Etching of same type as *Fig. 6*.

Fig. 5, but i

FIG. 5.—Rail which broke in service, causing a wreck. Shows result longitudinal defects in the ingot from which it was rolled.